An Evaluation of Core Inflation Dynamics and Its Impact on Macroeconomic Performance in India

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An Evaluation of Core Inflation Dynamics and Its Impact on Macroeconomic Performance in India

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This is to certify that the work presented in this dissertation entitled "*An Evaluation of Core Inflation Dynamics and Its Impact on Macroeconomic Performance in India*" by "*Arundhati Mallick*", Roll Number 512HS1009, is a record of original research carried out by her under my supervision and guidance in partial fulfilment of the requirements of the degree of *Doctor of Philosophy* in *Humanities and Social Sciences*. Neither this dissertation nor any part of it has been submitted for any degree or diploma to any institute or university in India or abroad.

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This thesis is dedicated

to

My Beloved Parents

Declaration of Originality

I, ArundhatiMallick, Roll Number 512HS1009 hereby declare that this dissertation entitled *"An Evaluation of Core Inflation Dynamics and Its Impact on Macroeconomic Performance in India"* represents my original work carried out as a doctoral student of NIT Rourkela and, to the best of my knowledge, it contains no material previously published or written by another person, nor any material presented for the award of any other degree or diploma of NIT Rourkela or any other institution. Any contribution made to this research by others, with whom I have worked at NIT Rourkela or elsewhere, is explicitly acknowledged in this dissertation. Works of other authors cited in this dissertation have been duly acknowledged under the section "Bibliography". I have also submitted my original research records to the scrutiny committee for evaluation of my dissertation.

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Abstract

The term ‘core inflation’ got popularised when central banks of some countries’ like, Australia, Finland, Canada, New Zealand, Spain, Sweden, and the United Kingdom shifted their focus to inflation targeting. These seven countries broke the tradition of exchange rate and multiple objectives of monetary policy frameworks and adopted one single objective of inflation targeting. Failure of other monetary policy regimes leads to adoption of this new monetary framework of inflation targeting. The monetary targeting framework failed in mid-1980 because of unstable demand for money function and the fixed exchange rate regime also collapsed in the early 1990’s. Canada and New Zealand are the first to adopt inflation targeting framework to improve the inflationary scenario of the economy later five other countries adopt inflation targeting, whereas their level of inflation was already comparatively low. These seven countries had a very poor record of fighting with high level of inflation for past 30 years before adopting inflation targeting framework. But after adopting inflation targeting, these countries have the record of both low inflation and monetary policy credibility. The main motives behind adopting inflation targeting or following core inflation are a low and stable inflation is a needed base for economic growth, and better macroeconomic performance. However, manipulating monetary policy in short period to achieve the goal of higher output or employment may create a conflict with price stability. Inflation targeting or maintaining a low and stable inflation can be possible if central banks follow a specific measure like core inflation.

Inflation in India is a serious and chronic problem because production depends on monsoon in agriculture sector, poor infrastructure facilities for transport of food items to the market and lack of proper storing facilities and energy import. The government has also historically heavily borrowed to finance its spending which leads to a high level of inflation due to high fiscal deficit. These are the main reasons of high inflation in India. The annual CPI from 1960 to 2016 has averaged at 7.6% in 16 of those years; CPI has been in double digits and above 6% in 35 of 56 years. Even in the post 1991 reform era, CPI has averaged above 6% for 17 of 25 years. India has been following the multiple objectives approach to conduct monetary policy. Recently, it has shifted to inflation targeting monetary policy framework. However, India is ready to adopt inflation targeting approach. Under inflation targeting approach, India has to focus on a single objective to maintain low inflation. To do this, it will focus on core inflation by ignoring supply side problem of inflation but for India supply side problem is more serious problem due to its poor infrastructure and tradition practice of farming. From the above reasons India adopted a flexible inflation targeting approach. That is, it adopted inflation targeting approach for short period of time from 5th August 2016 to March 31st 2021 and the level of inflation to be maintained is also flexible. This is good for making central bank of India for more accountable, transparent and improves the credibility of monetary policy.

To estimate core inflation, it is not justifiable to exclude food and fuel items from the price index. Every time all the food items are not volatile. Blindly excluding these items to get core inflation is not justified. So, our study tries to find out an alternative

measure of core inflation suitable for Indian economy. Other than finding an alternative measure of core inflation, the study also focuses what the other factors are contributing to India's inflation role of asset price and external shocks in India's inflation. A shock from world economy and fluctuations in asset price also affectsthe headline inflation. Hence, we need to find out volatility of these factors which has long term or short term impact on headline inflation. Short run impact form these fluctuations can be excluded while measuring core inflation. It is ensuring that the monetary policy of India needs to focus on core inflation. Other than the above problems, one of the major reasons to focus on core inflation is that, RBI as an authority to control monetary policy, other than targeting inflation, it also focuses on the growth rate. It has to manage the trade-off between growth rate and inflation rate. Ultimate and important motive of an economy is to achieve economic growth. Final aim of this study is to find out how above discussed factors are contributing to economic growth and macroeconomic performance of India.

To empirically analyse the study, we have used some simple statistical tools and some econometric techniques. Our first objective is to analyse the existing measures of core inflation for India and to check the dynamic relationship between headline and core inflation. To analyse this,in statistical approach, we have used the simple statistical tools like mean, standard deviation, covariance etc. and for model based approach we have used the econometrics technique like Structural Vector Auto Regression (SVAR). After getting all the series of core inflation, we try to find out the existing dynamic relation headline inflation and core inflation. We have used Vector Error Correction (VECM) Model to identify this dynamic relation. Our second objective is to find out the domestic and imported core inflation for India. Volatility in food prices are not the only reason, which creates short run or temporary fluctuations in the price index. Sometimes price of various commodities directly or indirectly get affected by changes in the world economy. To analyse this, first we separated goods of price index in to two categories i.e. tradable and non-tradable goods. Tradable goods are mostly associated with world economy and fluctuations in the world economy leads to affect the domestic economy through these goods and non-tradable goods purely represent the fluctuations in the domestic economy. In the first objective the study, we use WPI to represent the inflation but WPI does not include non-tradable goods or service sectors in the index, for this reason we use CPI instead of WPI to represent the inflation of the Indian economy. First, we categorise CPI index into two different sectors i.e. tradable and non-tradable goods, then we try to find out how fluctuations in the world economy transmitted to domestic economy through tradable goods by using Vector Auto-regression (VAR)model. The third objective of the study is to find out the role of asset in Indian inflation. Our main motive of this study is to identify all the possible sources that contribute to Indian inflation. To identify the role of asset price in Indian inflation, first we have added asset price into the commodity basket by assigning weightage to it. To assign weightage to the asset prices in commodity baskets, we use Neo-Edgeworthian Index. Finally, after assigning weights we use Kalman filter to estimate the forecasted inflation from both headline series of inflation and also from the inflation series including asset prices. Final and last objective of this study is to find out whether targeting core inflation really improving the macroeconomic performance of India or not. The ultimate objective of every country is to achieve economic growth and a stable economy. After identifying all the possible factors that are contributing to Indian inflation then, the study aims to find whether

adopting inflation targeting framework improves macroeconomic performance of the country or not. To empirically analyse this we use Vector Error Correction Model (VECM). We have also applied Impulse Response Function (IRF) to know how macroeconomic variables respond to any changes in core inflation.

As a result, we find that SVAR is a good measure to estimate core inflation but practically using it is difficult. But if we will see practical applicability of the measures then trimmed mean measure is better one. The study also finds that trimmed mean measure is performing better than the other two measure of core inflation. The study compares the performance of core inflation estimated from both the WPI and combined CPI but the result shows that trimmed mean measure of core inflation estimated from combined CPI outperform than trimmed mean measure of core inflation estimated from WPI inflation. While analysing the dynamic relationship between headline and core inflation, our result supports the findings of the previous studies that the speed and direction of adjustment between headline and core inflation depends on the different monetary regime. Any unexpected changes in the monetary policy affect consumer behaviour and also price level before consumers start considering rational expectation. In case of India we see that trimmed mean measure is giving better result than non-food manufacturing product measure and also holding the definition of core inflation. External shocks have an immediate effect on tradable inflation as it directly associates with external economy, while it takes time to affect the non-tradable inflation, as it affects the non-tradable sectors in the second round effect. Core inflation is estimated by excluding volatile goods from the consumption basket, but this volatility of the commodities may not be due to its nature of the commodity, rather be because of external shocks. Excluding these commodities does not fully extract the temporary fluctuations; there may be an existence of second round effect of external shocks in the core inflation. We also find that considering gold as commodity of consumption basket helps in predicting better level of inflation. But here the problem is that, asset prices are highly fluctuating; they are more volatile than the items in normal consumption baskets of individuals. So, we cannot react to all the movements of asset prices. If any movements in asset prices signals any inflationary or deflationary situation then, only monetary policy must react to asset price movements. That means we have to find out the misalignments of asset prices. After identifying all the possible factors that are contributing to Indian inflation we aim to find the impact of four different measures of core inflation on the macroeconomic performance of India. Except non-tradable inflation all other three measures of inflation highly affect the REER. In case of net trade also only CPI with gold is highly affecting the net trade. In response to the shock to all the measure of core inflation IIP reacts in a cyclical manner. Call money rate is also highly responsive to the shock of trim core inflation and CPI with gold.

Key Words: Core Inflation, Headline Inflation, VAR, VECM, India

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Abbreviation

AR:	Auto Regressive
ARMA:	Auto Regressive Moving Average
CCII:	CRISIL Core Inflation Indicator
CMR:	Call Money Rate
CPI:	Consumer Price Index
CRISIL:	Credit Rating Information Services of India Limited
CSO:	Central Statistical Organisation
DSGE:	Dynamic Stochastic General Equilibrium
EMDE:	Emerging Market and Developing Economies
FIT:	Flexible Inflation Targeting
GCC:	Gulf Cooperation Council
GDP:	Gross Domestic Product
HICP:	Harmonised Index of Consumer Prices
HP:	Hodrik-Prescott
ICOP:	International Crude Oil Price
IIP:	Index of Industrial Production
IIR:	Independent Inflation Rate
IMF:	International Monetary Fund
IRF:	Impulse Response Function
LIE:	Limited Influence Estimator
MAD:	Mean Absolute Deviation
NRI:	Non Residents of India
OECD:	Organisation for Economic Cooperation and Development
PCE:	Personal Consumption Expenditure
PDS:	Public Distribution System
RBI:	Reserve Bank of India
REER:	Real Effective Exchange Rate
RMSE:	Root Mean Square Error
RPI:	Retail Price Index
SD:	Standard Deviation
SIC:	Schwartz Information Criteria
SVAR:	Structural Vector Auto-Regression
TMVC:	Trim of Most Volatile Component
UCM:	Unobserved Components Model
UK:	United Kingdom
US:	United States
VAR:	Vector Auto-Regression
VECM:	Vector Error Correction Model
VD:	Variance Decomposition
VMA:	Vector Moving Average
WEO:	World Economic Outlook
WPI:	Wholesale Price Index
XFE:	Xtra Fuel Economy

Chapter 1

Background, Issues and Objectives of the Study

1.1. Introduction

Inflation is a very serious problem for any economy. It erodes savings, discourages investment, stimulates capital flight, inhabits growth, and hampers economic planning; and a high level of inflation for long period leads to social and political unrest. So, one of the major goals of the monetary policy is to maintain price stability of the economy. But central banks are facing serious problems of maintaining price stability because of the highly volatile nature of headline inflation. Headline inflation is mostly affected by non-monetary phenomena like relative price shocks and is beyond the control of monetary authority. Monetary policy operates with a lag by influencing the demand side. So, it faces problems in implementing policies when there is inflation in the economy due to supply shocks which are temporary in nature. If fluctuation in the current level of price is temporary, then it will automatically revert back to the current level of inflation. Reacting to these, temporary shocks will permanently decrease the level of employment. And to avoid these problems, central bank needs to forecast inflation apart from transitory movements. Here comes the term ‘core inflation’.

‘Core inflation’ represents the long run trend in the price level by excluding temporary fluctuations in the price level. Now-a-days, most of the central banks focus on core inflation rather than headline inflation, although controlling overall inflation is their main goal. Core inflation is a better instrument for the current monetary policy to control the future rate of inflation. The major difference between headline inflation and core inflation is that core inflation can be directly controlled by monetary policy whereas headline inflation cannot be. Headline inflation is an indicator of the changes in the cost of living while core inflation is an indicator for true changes in the price level. But still

there is confusion among central banks about focusing on core inflation. Many economists like Bullard (2011) argue that central banks should not focus on core inflation; it can be used as supplements to headline inflation but it cannot replace the headline inflation.

The term 'core inflation' got popularised when central banks of some countries' like, Australia, Finland, Canada, New Zealand, Spain, Sweden, and the United Kingdom shift their focus to inflation targeting. These seven small and medium countries break the tradition of exchange rate and multiple objective monetary policy framework and adopt one single objective of inflation targeting. Failure of other monetary policy regimes leads to adopt this new monetary framework of inflation targeting. The monetary targeting framework fails in the mid-1980s because of unstable demand for money function and the fixed exchange rate regime also collapses in the early 1990s. Canada and New Zealand were the first to adopt inflation targeting framework to improve the inflationary scenario of the economy. Later, five other countries have adopted inflation targeting, whereas their level of inflation was already comparatively low. These seven countries had a very poor record of fighting with high level of inflation for past 30 years before adopting inflation targeting framework. But after adopting inflation targeting these countries have the record of both low inflation and monetary policy credibility. The main motive behind adopting inflation targeting or following core inflation is that a low and stable inflation is a needed base for economic growth and better macroeconomic performance; and manipulating monetary policy in short period to achieve the goal of higher output or employment may create a conflict with price stability. Inflation targeting or maintaining a low and stable inflation can be possible, if central banks follow a specific measure for it like core inflation.

The term core inflation was first used by Schreder in 1952 to describe the situation of the inflationary gap in the US in 1950s. But, Otto Eckstein was the first person to come up with a formal definition of core inflation in 1981. According to him, core inflation is the "trend rate of increase of the price of aggregate supply." Core

inflation is associated with long run vertical Philips curve[1] where inflation is anticipated. He also divided core inflation into three subcomponents, i.e., demand shock, supply shock and production cost.

According to Quah and Vahey (1995) core inflation is "…. as that component of measured inflation that has no medium to long run impact on real output." Core inflation is about extracting transitory movements from overall or headline inflation. Transitory movements are unanticipated part of headline inflation, which has a short term impact on real output. But, core inflation consists of anticipated part of headline inflation, which does not have any impact on real output in medium to long run. In case of core inflation, there is no trade-off between inflation and output.

According to Roger (1998), the major difference between the definitions of core inflation of Otto Eckstein and Quah and Vahey is that Eckstein excludes the cyclical excess demand pressure as it is a part of unanticipated inflation, while Quah and vahey consider it as a component of anticipated inflation.

Eckstein's core inflation:

$$\pi_t^c = [\pi_t - g\,(x_{t-1}) - v_t] \rightarrow \text{trend inflation}$$

Quah and Vahey's core inflation:

$$\pi_t^c = [\pi_t - v_t] = \pi_t^{LR} + g\,(x_{t-1})$$

Where,

π_t = aggregate inflation rate at period t.

π_t^{LR}= trend inflation rate.

x_{t-1} = excess cyclical demand pressure

[1] Philips curve was developed by A.W. Philips, which shows the inverse relationship between unemployment rate and inflation rate. Later it was challenged by Milton Friedman and he developed Long run vertical Philips curve (augmented Philips curve). According to Friedman Philips curve holds in short run, in long run there is no trade-off between unemployment rate and inflation rate. So, the curve is vertical in the long run.

g = captures the effect of x on inflation.

v_t = measure temporary shocks to inflation.

According to Bryan and Cecchetti (1993), "In general when people use the term they seem to have in mind the long run or persistent component of the measured price index, which is tied in some way too many growth". Blinder (1997) mentioned core inflation is, "that durable part or persistent components of aggregate inflation". And that "…. the durable part of the information in each monthly inflation report was the part that was useful in medium and near term inflation forecasting".

1.2. Theoretical Debate on Measures of Core Inflation

The base line behind the term of core inflation is "inflation is always and everywhere a monetary phenomenon". This statement was given by American economist Milton Friedman in 1963. This statement is based on the Quantity Theory of Money[2]. There are two propositions related to this quantity theory. First, in the long run, the rate of inflation grows as the quantity of money increases. Second, in the long run, output and velocity of money remains constant with a permanent increase in money growth. This proposition proves that inflation is always and everywhere a monetary phenomenon. Also, according to Quah and Vahey definition of core inflation, it does not have a long run impact on real output. Core inflation is also focusing only on demand side fluctuations by excluding supply side fluctuations from headline inflation. Only demand side inflation can be controlled by monetary policy.

Core inflation is also based on Augmented Phillips Curve[3]. In augmented Phillips curve, adaptive expectation was introduced to the Phillips curve. According to Phillips curve there will be trade-off between inflation rate and unemployment rate when monetary authorities follow an expansionary policy. And according to adaptive

[2]The Quantity Theory of Money states a direct relationship between the quantity of money in an economy and the level of prices of goods and services sold. If the amount of money in the economy doubles, then the price level also doubles and causes inflation.

[3]The Augmented Phillips Curve introduces adaptive expectations into the Phillips Curve.

expectation it will work for the first round or the second round. It will not work for the third round as people will adjust their behaviour according to past experience. So Phillips curve is vertical in the long run. Phillips curve exists only in short periods. Core inflation also shows the long run trend in inflation. It ignores the short run temporary supply side fluctuations in the economy.

Other theory which supports monetary policy must focus on core inflation is New Keynesian Theory of Menu Cost[4].New Keynesian theories are focused on sticky prices and wages. According to the menu cost theory, adjusting price is costly because the need to send a new catalogue to costumers, to sales staffs, in case of a restaurant, it needs to reprint its menu card. Many argue that this cost is very small but it can make a huge loss if other firms do not change the price. A small change in menu cost can raise real money balance in the hand of customers and it can create demand for products of all firms. So, those entrepreneurs who bother for menu cost must focus on core inflation rather than headline inflation, because they can face a huge loss for any wrong decision.

It is known that there is neither any proper definition nor any proper measure exists for core inflation. So, even if some measures are being developed, it is difficult to know whether it is appropriate or not. Therefore, to know this, different studies have proposed different criteria for the measures of core inflation from different theoretical prospective. Some of the desired properties for core inflation measures are proposed by Roger (1997 & 1998). These properties are:

Timeliness: Core inflation must be available at the same time when new data on headline inflation are available. Otherwise, the importance and usefulness of core inflation will be reduced for policy makers.

[4]Menu cost is the result of price changes. An easy way to understand the term menu cost is by a typical example of restaurants. When a restaurant manager wants to change price, the cost of changing the menus, in order to show the new prices must be taken into consideration.

Robust and Unbiased:As per the definitions of core inflation, in the long run, core inflation and headline inflation must share the same long run trend. By applying Root Mean Square Error (RMSE) we can test whether headline inflation and core inflation follow the same trend or not.

Less Volatile in Nature:As we know core inflation measures the true underlying inflation, it must be less volatile by nature.Core inflation is measured by excluding temporary fluctuations from price series to decrease the risk of volatility.

Transparent and Easily Communicated to the Public: RBI always maintains transparency for strengthening accountability and credibility. To maintain this, RBI needs to calculate core inflation in such a way that it must be easily understood by the common people.

Predicting Future Headline Inflation: The most important objective behind measuring core inflation is to predict future headline inflation, so that when future rate of inflation is expected to exceed the target rate of inflation monetary authorities can tighten the economy. And similarly when future rate of inflation is expected to be less than the target level of inflation, monetary authorities can loosen the economy.

Verifiable: As we know there is no perfect or single measure of core inflation, it is a necessary condition for the core inflation to be verifiable. It must be possible to recalculate the measure of core inflation other than the originator.

Table: 1.1

Measures of Core Inflation Used by Different Central Banks across the World

Countries	**Core Measures**
Australia	CPI less mortgage interest payments, government controlled prices and energy prices
Belgium	CPI less potatoes, fruits and vegetables
Finland	CPI less housing capital costs, indirect taxes, and government subsidies
France	CPI less change in taxes, energy prices, food prices and regulated prices
Greece	CPI less food and fuel

Israel	CPI less government goods, housing, fruits and vegetables
Japan	CPI less fresh foods
Netherlands	CPI less vegetables, fruit and energy
New Zealand	CPI less commodity prices, government controlled prices, interest and credit charges
Philippines	A statistical trend line
Portugal	10 percent trimmed mean of the CPI
Singapore	CPI less cost of private road transportation and accommodation
Spain	CPI less mortgage interest payments
Sweden	CPI less housing mortgage interest and effects of taxes and subsidies
United Kingdom	Retail price index less mortgage interest
United States	CPI less food and energy items

Source: Various Central Bank Annual Reports

1.3. Core Inflation vs Targeting Inflation in India

A high level of inflation and its measures are always a serious problem for India since its independence. While the whole world was following CPI (Consumer Price Index) as its measure of inflation, India was looking to WPI (Wholesale Price Index) as its measure of inflation. CPI is true indicator about the people's cost of living. Indian has much form CPI index for different sections of people. It has different CPI index for rural population, for urban population, different index for industrial worker, agricultural labour, and manual labour. In this case considering CPI as the true index of inflation for India is too difficult. Finally, in 2010 central bank of India came up with a solution with new CPI index, i.e., combined CPI which includes CPI for rural area and CPI for urban area. Now India follows combine CPI as its general measure of headline inflation.

As we have already discussed, for India inflation is a serious chronic problem because of its dependence on monsoon in agriculture sector, poor road and infrastructure facilities to transport food items to the market and lack of proper storing facilities and energy import. The government has also historically heavily borrowed to finance its spending and leads to a high level of inflation because of high fiscal deficit. These are the main reasons of high inflation in India. If we see the statistical figures, we can find that annual CPI between 1960 and 2016 has averaged at 7.6% in 16 of those years; CPI

has been in double digits and above 6% in 35 of 56 years. Even in the post 1991 reform era, CPI has averaged above 6% for 17 of 25 years.

From the above discussions we can conclude that India must look for some alternative monetary policy framework to combat the chronic problem of inflation. India had been following the multiple objective approaches to conduct monetary policy. After shifting to combine CPI as its measure of headline inflation, it shifted to inflation targeting monetary policy framework. But, as a developing country India ready to adopt inflation targeting approach. Under inflation targeting approach India has to focus on a single objective of maintaining low inflation. To do this, it should focus on core inflation by ignoring supply side problem of inflation. But for India, supply side problem is a serious problem because of its poor infrastructure and tradition practice of farming. Because of above reasons India adopted a flexible inflation targeting approach. That is, it adopted inflation targeting approach for short period of time from 5th August 2016 to March 31st 2021 and the level of inflation to be maintained is also flexible. This is good for making central bank of India more accountable, transparent and improves the credibility of monetary policy.

1.4. Review of Literature

Various studies have been done on various aspects of measuring core inflation and about performance of inflation targeting monetary policy framework. After being a decade of adopting inflation targeting still debate is going on what is actual benefit of following it. Whether developing countries are ready to adopt inflation targeting framework or what is best and proper measure of core inflation to follow by countries? So, few recent literatures are discussed in the below table.

Table 1.2: Review of Some Recent Literatures

Study	Coverage	Methodology	Findings
Plessis, Rand and Kotze (2015)	1975:1-2008:12 monthly data of CPI, South Africa	Trimmed mean measure, exclusion approach, dynamic factor model and wavelet decomposition	In this paper the author compares four different methods of measuring core inflation to find the best predictability measure of core inflation. And, as a result, the study finds that wavelet approach is the best measure in forecasting inflation.
Stock and Watson (2015)	1959:1-2015:1 Monthly data of 17 components of inflation used to construct the US PCE index.	Unobserved Components Model with Stochastic Volatility, common Factors and Outlier Adjustment	The study empirically examines whether using disaggregated data on sectoral inflation improves the measurement of trend inflation. The study finds that, the estimated multivariate trend inflation is similar to the estimated univariate trend inflation and both the trend table to forecast an accurate level of inflation over 1-3 year horizon.
Alkhareif and Bamett (2015)	2012:3-2014:4 Monthly data of CPI, South Africa	Exclusion Method and statistical Method	This study constructs different measures of core inflation for South Africa. Among all the measures, the statistical measure of core inflation is relatively stable than any other measures of core inflation. While exclusion measure of core inflation found to be more volatile than headline CPI inflation.
Iwasaki and Kaihatsur (2016)	1981:1-2015:11 Monthly data of CPI Japan.	Dynamic Model Averaging as a weighted average of individual core indicators.	This study aims to suggest a new framework for measuring underlying inflation for Japan. The combine core indicator constructed by using dynamic model averaging performs better than individual core indicators.
Kalra and Dzung, (2002)	1999-2014 full sample period Two subsample period:1999-2007 and 2008-2014	Exclusion and Trimmed Mean Approach	This study examines the Vietnam's inflation process for two decades by dividing full sample into two sub-samples to construct robust core inflation measures. As a result the study finds that trimmed mean measure of core inflation outperform in comparison to the exclusion measure of core inflation.

Baciu (2015)	2005:06-2015:01 monthly data of CPI Romania.	Granger causality	The author aims to find the performance of measure of core inflation and its linkage with headline inflation after Romania adopted monetary policy framework of inflation targeting in August 2005. The study find that in short run only core inflation influences the headline inflation.
Wiesiolek and Kosior (2009)	1998:01-2009:03 Monthly data of CPI	Exclusion measure, 15% trimmed mean	This study aims to find out problem related to measure of core inflation used by Czech National Bank, the Magyar Nemzeti Bank and the National Bank of Poland. And the study finds that exclusion measure is associated with many problems but still monetary policy can use them as guide and communication tools.
Tekatli (2010)	2003:04-2010:04 Monthly data of CPI Turkey	Factor Model with the subcomponents of CPI inflation	The study tries to propose a new measure of core inflation for Turkey by using factor model with the subcomponents of CPI. After cross checking the properties of core inflation it is found that the new measure of core inflation is a good and useful measure of core inflation.
Ranchhod(2013)	2000-2012 CPI inflation of New Zealand	Exclusion Measure, Trimmed mean Measure and Dynamic Factor Model	The study analyses all the measures followed by central bank of New Zealand and finds the best measure among them. According to the study every measure of core inflation has its respective advantage. So, instead of focusing on any particular measure of core inflation we must follow a number of different approaches to measure core inflation.
Pedersen (2006)	1996:01-2000:12 Monthly data of CPI Euro Zone 1998:01-2005:06 Monthly data of US CPI	Trim of Most Volatile Component (TMVC): a combination of Trimmed mean and the Edgeworth Index	The study proposed a new measure of core inflation TMVC by combining trimmed mean and the Edgeworthian Index. The new measure of core inflation out performs in Euro Zone but in case of US the Edge worth Index performs better.

Araujo and Fiorencion (2005)	1994:08-2002:06 Monthly CPI data Brazil	Trimmed Mean and SVAR Measure	The study analyses the frequency domain properties of trimmed mean and SVAR measure of core inflation. Trimmed performed better than SVAR measure of core inflation. Trimmed mean capture the trend inflation better in comparison to SVAR measure of core inflation.
Holtemoller and Mallick (2016)	1996:Q2-2013Q2	SVAR Measure	The study analyses the effect of price movements in the global economy on poor. As a result, the study finds that, the main reason behind variation in inflation in India is cost push mainly during the period of 2008 and 2010 and also supply shocks are main contributor to the inflation in India.
Mallick (2004)	1950-1995	Fully modified Phillips-Hansen Method	This study aims to examine the different determinants of India's trade and inflation. The study finds that trade balance effects of tight credit policy are more enduring than that of devaluation. Devaluation actually worsens trade balance and hence devaluation cannot be an option in response to negative trade shock.
Mallick (2005)	1950-1995	Supply side model of inflation determination in addition to the standard demand framework	The study examines the determinants of India's trade and inflation after the effects of reform policy implemented in 1991 and found that reduction in domestic credit reflecting demand contraction can produce a desirable improvement in the trade balance.
Mallick and Sousa (2011)	1990:01-2008:04 BRICS countries	B-SVAR Framework	This paper examines the monetary policy transmission for five key emerging market economies: Brazil, Russia, India, China and South Africa. Contraction monetary policy has a strong and negative effect on output.

Source: Author's Compilation

1.5. Statement of the Problem

The study of core inflation is an emerging issuefor many developing countries. Even after many studies and researches have been done across different countries, still it is

debatable whether central banks should focus on core inflation or headline inflation. The existing measures of core inflation are also questionable because, on the one hand, measures with proper economic interpretation are not easy to use practically and on the other hand measures used generally for measuring core do not have a proper economic interpretation.

Many studies have not been done on the measures of core inflation in India. The existing studies again are limited in the sense that, they have examined different measures of core inflation in the context of India, but none of them have suggested as to which measure is suitable for the Indian economy. Generally central banks follow exclusion method for estimating core inflation, because of the easy estimation and communication to the public. But it is not suitable for Indian economy. Exclusion approach for core inflation was first introduced by the Bureau of Labour Statistics in the U.S.A. In the U.S.A, this measure concerns to the urban population where the weightage of food and energy items are around 22 percent, but in the case of India, weightage of food energy items is around 45 percent, excluding 45 percent of the weightage from WPI index means taking away half of the weightage from its index. Other measures of core inflation are complicated in estimating core inflation and to communicate with the public.

Exclusion measure of core inflation is quite suitable to developed economy, but it is not appropriate for a developing economy like India, where it has different price index to represent different section of the population. WPI is generally used as main index to represent Indian inflation but it has many drawbacks, i.e., it mainly represents industrial section, it does not include service or non-tradable goods. Service sector and non-tradable goods also contribute to domestic inflation. Other than WPI, CPI is also another measure to represent the inflation, but it has two different indices to represent urban and rural population of India separately. Finally, one consolidates CPI which includes both urban and rural population was constructed to represent India's inflation. In this context, focusing to particular price index as headline inflation and conducting monetary policy is

difficult. While, conducting monetary policy it has to exclude short term and temporary fluctuations and find out the factors that contribute to Indian inflation in long term.

1.6. Significance of the Study

As it has already been discussed earlier, exclusion measure is the most preferred measure of core inflation, but how far it is applicable for Indian economy. Since India is a developing country, the level of income and standard of living of most of the people are very low. According to Arjun Sengupta Commission report (2007), 77 percent of the Indian population spend less than Rs. 20 per head in a day. As their standard of living is very low their consumption basket mainly consists of food and energy item. Therefore, food inflation is a very serious problem for India. With a large growing population, it is very difficult to manage food supply according to its demand level. India's population is growing faster, but the availability of food is not growing. The annual per capita cereal availability in India in 2008-09 was only around 165 kg, which was the same as in 2000-01. The immediate reason behind the price rise of some specific food items are hoarding of those food items, agricultural crisis, weakened Public Distribution System (PDS), cuts in the subsidies and price hikes of inputs like diesel and fertilisers. And controlling these factors for managing prices of food items are not in the hands of the monetary authorities, so it needs to focus on core inflation. In case of oil price, the international crude oil price was ranging between 85 to 90 dollars per barrel in 2011. As per the exchange rate in 2011, price of crude oil is around Rs. 25 per litre while the retail price of petroleum ranged between Rs. 58 to Rs. 63 per litre. The huge difference between crude oil price and the price of petrol is due to the increase in customs and excise duties. Later on the price of crude oil increased because of the political crisis in the Middle East.

The economic scenario of India suggests following core inflation for conducting monetary policy rather than headline inflation. But, totally excluding food and fuel items from the price index is not justifiable. Every time all the food items are not volatile. With good monsoon, sometimes price of food item remains stable. Blindly excluding these items to get core inflation is not justified. So our study tries to find out an alternative

measure of core inflation suitable for Indian economy. Other than finding an alternative measure of core inflation, the study also focuses on finding what are other factors contributing to India's inflation role of asset price and external shocks in India's inflation. Shocks from world economy and fluctuations in asset price also affect headline inflation. So, we need to find out volatility of these factors that has long term or short term impact on headline inflation. Short run impact form these fluctuations can be excluded while measuring core inflation.

From the above discussion, it is ensured that the monetary policy of India needs to focus on core inflation. Other than the above problems, one of the major reasons to focus on core inflation is that RBI as an authority to control monetary policy is not an inflation targeting one. Other than targeting inflation, it also focuses on the growth rate. It has to manage the trade-off between growth rate and inflation rate. Ultimate and important motive of an economy is to achieve economic growth. Final aim of the study is to find out how the above discussed factors such as external shocks and asset price are contributing to the economic growth and macroeconomic performance of India.

1.7. Objectives of the Study

The present study broadly examines or measures the core inflation in India. Specifically, the objectives are:

(1) To evaluate the existing measures of core inflation, such as exclusion method, limited influence estimator and structural vector auto regression method.
(2) To identify the domestic and imported core inflation of India.
(3) To examine the role of asset price in inflation in India.
(4) To examine the impact of core inflation on macroeconomic variables in India.

1.8. Data and Methodology of the Study

The present study uses secondary data available from different published sources. It uses monthly data of WPI series,Index of Industrial Production (IIP), International Crude Oil

Price (ICOP), Real Effective Exchange Rate (REER), Call Money Rate (CMR) as short run domestic interest rate and monetary aggregates (M3) from January 2000 to April 2016 with base year of 2004-05. The study also uses CPI combine data but as it is available only from 2010, we have back casted the CPI data by establishing a relationship between these two series for the common sample period. The data are collected from secondary sources such as Hand Book of Statistics and Data Base of Indian Economy published by Reserve Bank of India (RBI), Central Statistical Organisation (CSO) of the Government of India, International Financial Statistics (IFS) published by International Monetary Fund and World Development Indicators (WDI) published by World Bank. The ICOP data is not generating by any international or national Govt. Organization. Hence, ICOP data are collected from the private sources like Bloomberg (www.bloomberg.com).

To empirically analyse the study, we use some simple statistical tools and some econometric techniques. All the measures of core inflation are broadly divided into two categories, i.e., statistical approach and model based approach. Our first objective is to analyse the existing measures of core inflation suitable for India and the dynamic relationship between headline and core inflation. To analyse the statistical approach, we are using the simple statistical tools like mean, standard deviation, covariance etc. and for model based approach we are using the econometrics techniques like Structural Vector Auto Regression (SVAR). SVAR was developed by Sims (1986) and Bernanke (1986).The standard VAR was developed by Sims in 1980, but it was criticised on the ground that it does not use any economic theory; it only helps in recovering the structural innovations from residuals by using Cholesky decomposition. To overcome from these problems, Structural VAR was introduced. The major difference between standard VAR and Structural VAR is the use of economic theory. Structural VAR can be identified from reduced form of VAR model. It is helpful to separate out the economically unrelated influences in price index and also useful for forecasting purpose. After getting all the series of core inflation we try to find out the existing dynamic relation headline inflation and core inflation. We use Vector Error Correction (VECM) Model to identify this dynamic relation.

Our second objective is to find out the domestic and imported core inflation for India. Volatility in food prices are not the only reason which creates short run or temporary fluctuations in the price index. Sometimes price of various commodities directly or indirectly get affected by the changes in the world economy. This objective aims to find out, which are the commodities that attract inflation from the world economy. To analyse this, first we separated goods of price index into two categories, i.e., tradable and non-tradable goods. Tradable goods are mostly associated with world economy and fluctuations in the world economy leads to affect the domestic economy through theses goods; and non-tradable goods purely represent the fluctuations in the domestic economy. In the first objective the study use WPI to represent the inflation but WPI does not include non-tradable goods or service sectors in the index. Therefore, we use CPI instead of WPI to represent the inflation of the Indian economy. First, we use factor analysis to categorise CPI index into two different sectors, i.e., tradable and non-tradable goods; and then we try to find out how fluctuations in the world economy transmitted to domestic economy through tradable goods by using Vector Auto-regression (VAR) model.

The third objective of the study is to find out the role of asset price in Indian inflation. Our main motives of the study are to identify all the possible sources that contribute to Indian inflation. According to Alchain and Klein (1972), instead of looking into only current consumption basket for measuring inflation, we must focus on the current cost of expected life time consumption as people lives in two periods. So, we also need to consider the future expectations of individuals. We are considering individuals' investment in future or their behaviour towards future expectations of prices, and we must consider asset prices as indicator of these things, because asset prices can better represent the future movement of prices. Also, we can identify aspiring credit bubbles and take necessary monetary policy actions according to that. To identify the role of asset price in Indian inflation, first we added asset price in to the commodity basket by assigning weightage to it. We use Neo-Edgeworthian Index to assign weightage to the asset prices in commodity baskets. Finally, after assigning weightage we use Kalman

Filter to estimate the forecasted inflation from both headline series of inflation and also from the inflation series including asset prices.

Final and last objective of this study is to find out whether targeting core inflation really improving the macroeconomic performance of India or not. The ultimate objective of every country is to achieve economic growth and a stable economy. After identifying all the possible factors that contributing to Indian inflation, the study aims to find out whether adopting inflation targeting framework improves macroeconomic performance of the country or not. It is believed that price stability is the pre-condition for sustained economic development from every aspect. In this objective we are examining how all the measures of core inflation we get from above mentioned three objectives contribute to macroeconomic performance of the economy. To empirically analyse this, we use Vector Error Correction Model (VECM). We have also applied Impulse Response Function (IRF) and Variance Decomposition (VD) to know how macroeconomic variables response to any changes in core inflation.

1.9. Chapter Outline

The present study is organised into six chapters including the present one. This chapter covers the background, issues and objectives of the study. It mainly discusses the overview and origin of the core inflation and different measures implemented by different countries including India. Both the theoretical and empirical literatures relating to core inflation is being addressed. The study subsequently comprehends significance, objectives, methodology, data sources, time period and econometric tools used for the study. This chapter also elaborate India's view point adoption of flexible inflation targeting framework and following of both headline and core inflation to conduct monetary policy. The second chapter tries to figure out the evaluation of different measures of core inflation. First we discuss about the overview of the different existing measure to core inflation, which include both statistical approach and model based Approach. Next we explain the three best major approaches such as exclusion measure,

trimmed mean approach and structural VAR approach relating to the importance of measures of core inflation. At the end of this chapter, we empirically compare the abovethree approaches and also identify the dynamic the dynamic relation between headline and core inflation for Indian economy.Third chapter identifies the domestic and imported core inflation in India. This chapter provides a brief description of the India and its external sector behaviour with respect to both domestic and imported core inflation. It gives a brief idea about the above core inflation origin and splits the headline inflation into tradable and non-tradable inflation, then tries to find out how it is responding to external shocks. Further, it empirically analyses,how fluctuations in the world economy transmitted to domestic economy through tradable goods.The fourth chapter tries to find out the role of asset prices on inflation in India. The main purpose of this chapter is to identify the features of asset price by including gold and equity price into the consumption basket of Indian economy. Neo-Edgeworthian Index and Kalman Filter models used to assign weights, according to their respective standard deviation and then try to forecast the inflation. The Fifth chapter deals with the impact of core inflation on macroeconomic variables in India. First it gives the brief portrayal of the targeting core inflation and the macroeconomic performance. This follows the comparison study between core inflation and headline inflation. Then it highlights empirically the importance of core inflation instead of headline inflation to improve the macroeconomic performance of the country.Finally, sixth chapter summarizes the findings of the study and presents the conclusions of the study. In this chapter, we put forward few policy recommendations with the aim to improve macro-economic scenario of the country by taking care of core inflation in to account. Finally, we briefly discuss the limitation of the study, scope for further research and significant contribution to the existing literature.

Chapter 2

Evaluation of Different Measures of Core Inflation

2.1. Introduction

Inflation is a serious problem for India. The recent hikes in international oil price lead to rise in inflation rate. Other than the rise in international oil price, rise of food prices and depreciation of currency also leads to rise in the overall level of inflation. Price stability is one of the important goals of monetary policy and it manages to combat high rate of inflation. However, among all shocks, some shocks are temporary in nature; reacting to those temporary shocks is more worsen the economic situation. Hence, in this case, central bank must follow core inflation rather than headline inflation. Reserve Bank of India (RBI) is an authority to control monetary policy with objective of price stability and economic growth. It has to manage the trade-off between growth rate and inflationrate. If RBI focuses on core inflation, it is easy to manage the trade-off between the growth and the inflation rate. India, very recently from 2014 onwards, started targeting inflation and changes its measure of inflation from Wholesale Price Index (WPI) to Consumer Price Index (CPI). 'Core inflation' represents the long run trend in the price level by excluding temporary fluctuations in the price level. Otto Eckstein was the first person to come up with a formal definition of core inflation in 1981. According to him, core inflation is the "trend rate of increase of the price of aggregate supply." Core inflation is associated with the long run vertical Philips curve where inflation is anticipated. He also divided core inflation into three subcomponents: (i) demand shock, (ii) supply shock and (iii) production cost. According to Quah and Vahey (1995), core inflation is "… as that component of measured inflation that has no medium to long run impact on real output". Core inflation is about extracting transitory movements from overall or headline inflation. Transitory movements are unanticipated part of headline inflation, which has a short term impact on real output. However, core inflation consists

of anticipated part of headline inflation, which does not have any impact on real output in medium to long run.

Although core inflation is more preferable than headline inflation, it does not have any proper measure. Still most of the countries' central banks prefer core inflation along with headline inflation for monetary policy purpose. It cannot directly get the series of core inflation. It has to be estimated from headline inflation. All the measures of core inflation are broadly divided into two approaches, i.e., (a) statistical approach and (b) model based approach. Statistical approach includes simple statistical tools like mean, median, standard deviation, covariance to estimate core inflation. The measures under statistical approach don't have any proper economic interpretation; still the central banks mostly prefer the measures under this approach because of its easy calculation and easy communication with public. Different measures under statistical approach are exclusion measure, limited influence measure, persistence measure, doubles weighted measure etc. The Model based approach is more rationale than measures under statistical approach. The measure under this approach is more efficient than the statistical approach measures as it is providing a proper economic interpretation. But the problem with it is difficult to estimate and also difficult to communicate with the public.

Among all the statistical approaches, principally, central banks prefer exclusion approach because of its easy calculation and communication with public. In this approach it excludes most volatile commodities from the index, and then calculates core inflation. Generally, price of food and energy are considered as the most volatile commodities. So, mostly preferable exclusion methods are ex-food, ex-energy or both together. But this is not an appropriate method to calculate core inflation; volatile commodity in one period may not be volatile in next period. So, continuously excluding only few commodities is not a good method. In this case, Limited Influence Estimator (LIE) is more appropriate than exclusion method, because it revised volatility of the commodities in each period. Still most of the countries follow exclusion method rather than LIE. Very few countries like Portugal use LIE (10% trimmed mean) to calculate core inflation. Other than this, the statistical approach Structural Vector Auto Regression

(SVAR) is also a good method to calculate core inflation. But, it is difficult to estimate and also to communicate with the public.

In India, the Reserve Bank of India (RBI), while following WPI as the measure of Inflation, uses non-food manufacturing inflation as the core inflation measure. But, now it uses CPI as the measure of inflation and uses different exclusion measures like exclusion of food and beverages from CPI, exclusion of both food and fuel from CPI etc. Using the above mentioned measure as a core inflation measure means excluding around 50% weight from the price index; that means we are losing too many information. Credit Rating Information Services of India Limited (CRISIL) criticised the RBI's method of measuring core inflation and introduced an alternative measure of core inflation for India known as CRISIL Core Inflation Indicator (CCII). This new measure of core inflation includes processed food and takes out base metals. It includes processed food to capture the second-round effect of impact of supply shocks and it excludes base metals, because their prices are directly influenced by international prices. CCII purely measures the domestic demand pressures as it excludes base metals. Non-manufacturing inflation and CCII both had similar trend in 2012, but gradually CCII started decline. As per May 2014, both non-food manufacturing inflation and CCII was 3.8%. CCII can be a better measure than non-food manufacturing measure but not an appropriate one. It excludes base metals to avoid the fluctuations in the domestic economy due to fluctuations in international prices, but in an open economy it is not possible to implement policies avoiding such situations. CCII still gives a misleading figure.

2.1.1. An Overview of the Different Existing Measures of Core Inflation

Although core inflation does not have any proper measure still most of the countries' central banks prefer core inflation along with headline inflation for monetary policy purpose. We cannot directly get the series of core inflation. It has to be estimated from headline inflation. All the measures of core inflation are broadly divided into two approaches. Those are:

1. Statistical approach
2. Model based approach

2.1.1.1. Statistical Approach

Statistical approach includes simple statistical tools like mean, median, standard deviation, covariance to estimate core inflation. The measures under statistical approach don't have any proper economic interpretation; still the central banks mostly prefer the measures under this approach because of its easy calculation and easy communication with public. Different measures under statistical approach are discussed below.

(a) Exclusion Measure

The most famous and widely used measure of core inflation is exclusion based core measure. In this measure we exclude most volatile commodities from commodity basket and then calculate inflation; and for testing the volatility of the commodities, generally we use standard deviation and variance. Most of the central banks found food and energy as the most volatile commodities in nature. So, most of the countries follow ex- food and energy as their measures for core inflation. Ex- food and energy is not the only measure of exclusion based core inflation; exclusion of commodities varies from country to country based on the consumption pattern of their people. For example, Canada excludes indirect taxes from CPI (Consumer Price Index) along with food and energy item. Spain excludes only mortgage interest payments from CPI. Some countries exclude only energy from CPI. This ex- energy measure was developed by Clark (2001).

(b) Limited Influence Measure

Limited influence approach was developed by Bryan and Cecchetti (1994). Bryan and Cecchetti used Ball and Mankiw's model to develop this measure which states that the aggregate inflation can be divided into demand driven inflation and supply shocks. In this measure, core inflation constitutes a weighted average of price changes after excluding some percentage of volatility from both the tails. So, it is also known as trimmed mean measure. It can be calculated in two ways. First, we use 10 percent trimmed mean (trimmed 5 percent from both the tail) to calculate core inflation, then rescale the weights of remaining component in the consumption basket and take a weighted average to calculate core inflation. Second, we can directly take the weighted average of timed series to calculate core inflation. Wynne (1999) argues that after

trimming the series, we can directly take the weighted average, no need to re-scaling the weight as we are focusing on core inflation and weighting system represents the cost of living.

(c) Exponential Smoothed Measure

The Exponential smoothed measure was developed by Cogley (2002) aiming to capture the changes in mean inflation. According to Cogley, core inflation must be designed in a way that it must be able to adopt the changes in mean inflation. These changes in mean inflation take place due to policy changes and adding up of new data, so this method is designed with one sided geometric distributed lag of past inflation.

$$\mu_t = g_0 \sum_j (1 - g_0)^j \pi_{t-j}$$

Where μ_t is the exponential smoothed series, π_t is the actual rate of inflation and g_0 is the gain which is standardized based on the values suggested by Cogley. It differs from limited influence approaches in the context that it is one sided filter method.

(d) Persistence Measure

This is a very rarely used approach for measuring core inflation. This approach is almost similar to exclusion approach. In exclusion approach, it excludes commodities having high variance; while in persistence approach, it excludes commodities having high frequency. The persistence of component is measured by using Auto Regressive (AR) method. In literature this method has been used in two ways. First, Cutler (2001) estimates AR model and then ranked the magnitude of the autoregressive coefficients. Second, Bilke and Stracca (2007) took the sum of the estimated auto regressive components. Cutler estimated following AR model using monthly data and annual inflation rates.

$$\pi_{i,t} = \alpha_{i,t} + \rho_{i,t} \pi_{i,t-12} + €_{i,t}$$

If the coefficient of estimated model is negative, then it is very fast mean reversion, so zero weight will be given to that commodity. The problem with this measure is in the

specification of Autoregressive model. Again, this measure was used by Bilke and Stracca in their paper. They analysed following model:

$$\pi_{i,t} = \alpha_{i,t} + \sum_{j=1}^{qi} \gamma_j \pi_{i,t-j} + \epsilon_{i,t}$$

In this model, we used Schwartz Information Criteria (SIC) to choose the lag length. The persistence measure is the sum of the estimated autoregressive component. In proportion to the magnitude of the summed AR weights the inflation rates are re-weighted.

(e) Double Weighted Measure

Like the literal meaning of double weight, the components of price index are weighted twice for measuring core inflation. First one is done by its expenditure share and the second one is by the reciprocal of the standard deviation of the relative price changes. The advantage of this measure is that losing of any valuable information is very less.

(f) The Hodrik-Prescott (HP) Filter

Generally, the HP filter is used to extract cyclical movements in time series. The function of the HP filter based on the assumption that the non-stationary movements in time series are captured by both smooth and slowly changing trends. It is very useful in measuring business cycle movements. It is also able to decompose time series into two unobservable components. Suppose the series (x_t) is composed of the trend component (g_t) and cyclical component (c_t).

$$x_t = g_t + c_t$$

Then HP filter isolates the cyclical component by minimising.

$$\sum_{t-1}^{T}(x_t - g_t)^2 + \lambda \sum_{t-2}^{T-1}[(g_{t+1} - g_t) - (g_t - g_{t-1})]^2$$

The equation is divided into two different terms; first denotes the measure of the fitness of the time series and second is the measure of the smoothness. Like other measures, there is trade-off between goodness of fit and smoothness. Here λ is the trade-off

parameter. If the value of λ=0, then the series will be equal to the original series. If the value of λ is greater than 0, then the series is an approximate linear trend.

2.1.1.2. Model Based Approach

The Model based approach is more rationale than the measures under statistical approach. The measure under this approach is more efficient than statistical approach measures as it is providing a proper economic interpretation. But, the problem is that it is difficult to estimate and also difficult to communicate with public. Measure under the model based approach is discussed below:

(a) Structural VAR Measure

The Structural VAR (SVAR) measure was developed by Quah and Vahey (1995). According to them, core inflation has no impact on real output in the long run. Other than prices, core inflation is also affect and affected by other macroeconomic variables. So Quah and Vahey used real GDP to analyse core inflation. They start with a bivariate VAR model; other researchers such as Blix (1995), Folkertsma and Hubrich (2000), Baglino and Morana (2003) expand it to multivariate SVAR model by integrating other macro variables. The assistance of this model is that it is based on monetary theory, while its shortcomings relate to the specification and identification of the SVAR model; also it is difficult to understand by the public.

We have discussed above the different measures to estimate core inflation. Among all the measures, most of the central banks use exclusion method to estimate core inflation; except a few who use trimmed mean method to estimate core inflation. Many central banks prefer exclusion method, but all of the central banks don't exclude any one or two commodities unanimously. They exclude different commodities according to the volatility of commodities based on their economic conditions.

The rest of the chapter is divided into eight sections including the introduction one and overview of the different existing measures of core inflation. The second section gives an overview about the existing literature about different measures of core inflation.

The third, fourth and fifth section discusses bout exclusion, trimmed mean and SVAR measure of core inflation respectively. Theses sections also empirically constructed respective measure of core inflation for India. The sixth compares the above mentioned three measure of core inflation by seeing their descriptive statistics. Then seventh section tries to find out the existing relationship between headline and core inflation by analysing the adjustment coefficient among them through VECM.Finally, section eight draws the conclusion.

2.2. Review of Literature

There are many studies that focus on different alternative measures of core inflation for different countries. A recent study by Bicchal, Sharma, Kamaiah (2012) discussed different existing approach to measure core inflation and analyse advantages and disadvantages of different approach. To construct core inflation measure they used monthly WPI data from April 1994 to March 2007 and followed exclusion, re-weighted and weighted exponential approach. In exclusion approach, they constructed two series; one series excludes food and energy and another series excludes fifteen most volatile components. They found that weighted exponential smoothing based measure of core inflation is better than any other measure in terms of lower volatility, tracking trend inflation and an ability to predict future transient movement in headline inflation both at 12 months and 24 months' horizon.

Similarly, a study by Aghajanyan (2005) examined the best measure of core inflation for a small transition country Armenia. The author compared exclusion method, the median, the weighted median, double weighted indices, trimmed mean indices and the Hodrick-Prescott filter by using monthly CPI data from 1996:1-2002:12. To find the best and efficiency measure of core inflation author examined following facts; first, the maximum correlation with monetary aggregates and second, the maximum correlation with future inflation and the minimum root mean square error (RMSE), and the mean absolute deviation (MAD). As a result, the author found that the core inflation measure that is closely related to inflation trends need not be closely related to monetary policy

actions. So, RMSE and MAD are necessary criteria but not sufficient criteria. Core inflation calculated by 10% or 15% trimmed mean is optimal indicators for monetary policy purposes in Armenia; and the median is the best inflation forecaster among all measures of core inflation.

Smith (2005) examined the interaction of core inflation and inflation targeting as a monetary policy regime. The author conducted a cross section study to examine this and found that core inflation is dependent on the monetary policy regime. There is not much difference between non inflation targeters and inflation targeters after inflation targeting begins. Rich and Steindel (2007) compared different propose measure of US core inflation. But, the study did not able to find any particular measure which is better in all the criteria for the best measure.

Cogley (2002) proposed a new measure of core inflation, known as exponential smooth measure which is designed to track sudden and persistent movements in inflation arising from changes on monetary policy. In this measure, government and private sector use adaptive method to know about the changing mean inflation in the economy. The measure filters out transients more effectively than the existing measures. This measure is a superior predictor in combination with macroeconomic predictors of inflation, and it contains substantial incremental predictive power relative to the macro variables.

Quah and Vahey (1995) recognised that there is conceptually mismatched between measured Retail Prices Index (RPI) inflation and core inflation. The RPI did not accurately capture the inflation. Here, they proposed a technique for measuring the core inflation based on an explicit long run economic hypothesis. They defined core inflation as the component of measured inflation that has no medium or long term impact on real output- consistent with a vertical long run Phillips curve.

Mallick (2015) examines the interactions of business cycle in India and its macroeconomic policy during the post reform period. The study found that regular intervention of central banks makes real effective exchange rate stable while the nominal

effective exchange rate shows a depreciating trend and the accumulated inflation differentials of India over its trading partners contributed to the collapse of rupee in 2013.

Even many studies criticised of focusing core inflation. Bullard (2011) stated that monetary policy' main focus is to control overall level of inflation. Core inflation is only a most famous subset of overall inflation. According to him, focusing on core inflation means misguiding the people; central bank must focus on headline inflation. To prove this, he argued on various ground that core inflation is a rotten concept. He argued that many monetary policies use existing policy designed for core inflation to estimate headline inflation, which gives a volatility result. Most of the economists justify using core inflation as a good predictor of headline inflation, but Bullard argue that while trying to predict future headline inflation we generally use misspecified model as core inflation is acting as proxy for all the variables, so it cannot be a good predictor of future headline inflation. He also argues that relative price changes are already accounted in existing price indices that means if price index rises there is really inflation exists in the economy. Using relative price change concept to explain increase in price index is inappropriate.

Table 2.1
Review of Some Recent Literatures

Study	**Coverage**	**Methodology**	**Findings**
Mazumder, (2014)	1982:1-2010:2 Both quarterly and monthly data of XFE prices for 22 OECD countries	Ball's sacrifice ratio Zhang's sacrifice ratio Hofstetter's sacrifice ratio	In this paper the author tried to investigate what happens if core inflation is used to both identify disinflation episodes and measure the sacrifice ratio. As a result, they found that headline inflation produces more disinflation episodes than core inflation and episodes that are generally shorter in length. Also found that the argument in favour of the cold-turkey.

Sherawat and Giri, (2013)	2004:3-2012:12 Monthly data of WPI	SVAR approach	They suggested that monetary policy must use core inflation instead of headline inflation to avoid the problem of temporary supply shocks. Other than this by conducting co integration test they found that, both headline inflation and core inflation has long run relationship with industrial production, reserve money, broad money, gold prices and crude oil prices.
Kar(2010)	1970:3-2006:11 Monthly data of WPI	Unobserved Components Model(decomposition of time series data)	The study suggested UCM as an alternative to SVAR approach for measuring core inflation. This method gives an inflation rate, which doesn't have any seasonal and irregular variations.
Durai and Ramchandran, (2007)	1994:4-2005:3 Monthly data of WPI	exclusion method, limited influence method and common trends model	The study tried to find out how well different measures satisfy certain desirable properties of core inflation and finds that core inflation estimated from common trends model consistently passed all the empirical tests and are less volatile, co integrated with headline inflation and unbiased to headline inflation.
Arrazola and Hevia, (2002)	1987:1-2000:8 Monthly data on five basic components of the Spanish CPI	Independent Inflation Rate (IIR)	The author proposed an alternative measures of core inflation i.e. IIR, which is obtained so that it is contemporarily orthogonal to the changes in relative prices.

Source: Author's Compilation

2.3. Exclusion Measure of Core Inflation

Exclusion measure of core inflation is most widely followed method of estimating core inflation among inflation targeting countries. Freeman (1998) examined the forecasting ability of the two core inflation measures. Those measures are median CPI and CPI less food and energy. By conducting co integration test he found that both the core inflation measures are co integrating with total inflation that means both the core measures have long run relationship with total inflation. To test the forecasting ability of the both measures, the author conducted granger causality test using the error correction

methodology. As a result, he found that any divergences of both the measures of core inflation from headline inflation are reverting back to headline inflation quickly, but the practical applicability of the core inflation for forecasting purpose is nil.

Lafleche and Armour (2006) evaluated the core inflation measure followed by Bank of Canada. In 2001, Bank of Canada replaces CPI excluding food and energy with CPIX (excludes eight most volatile commodities). The study aims to evaluate whether this newly adopted core inflation measure is better than other existing measures of core inflation or not. As a result, they found that the newly adopted measure outperform in all the criteria although it loses many information. Therefore, bank of Canada can continue CPIX as official measure of core inflation and also simultaneously continue to monitor the other measures of core inflation.

Raj and Misra (2011) analysed six exclusions based measures of core inflation in India based on the new series of WPI with base year 2004-05. These six measures are: WPI excluding food; WPI excluding fuel; WPI excluding food and fuel; non-food manufacturing; WPI excluding fuel and basic metals and metal products; and WPI excluding fuel, metals group and food primary articles. These six measures were tested for three properties of core measures; (a) volatility, (b) unbiasedness and capability to track trend, and (c) predictive power. As a result, they found that non-food manufacturing which is generally used by Reserve Bank as a measure of demand side pressure satisfies all the properties of core measure. They also concluded that the core measures are useful only as an indicator of the underlying inflation rather than as policy targets. Core inflation measures cannot be used as a substitute for measures of headline inflation. However, they could be a short term operational guide for monetary policy.

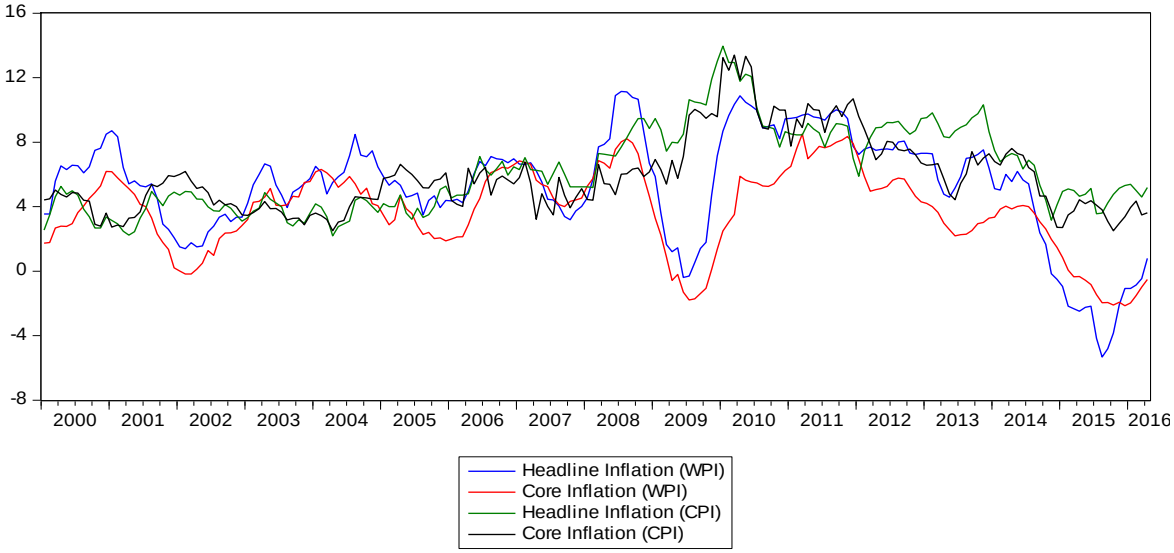


Figure 2.1: Headline Inflation and Core Inflation (Exclusion Measure)
Source: Author's Calculation

The above figure 2.1 represents the core inflation estimated from both WPI and CPI by using exclusion measure of core inflation. In case of WPI, we estimated non-food-manufacturing WPI inflation as core inflation. Considering food and fuel as the most volatile commodities in consumption basket we excluded these items from the index to estimate exclusion based core inflation measure for India. In case of CPI we have also excluded both food and fuel items to estimate core inflation. The above figure 2.1 also shows that WPI is highly volatile in nature as core inflation is estimated from it. CPI is more stable than WPI inflation and also core inflation estimated from CPI inflation index.

2.4. Trimmed Mean Approach of Core Inflation

Limited influence approach was developed by Bryan and Cecchetti (1994). Bryan and Cecchetti used Ball and Mankiw's model to develop this measure which states that the aggregate inflation can be divided into demand driven inflation and supply shocks. In this measure core inflation constitutes a weighted average of price changes after excluding some percentage of volatility from both the tails. Hence, it is also known as trimmed mean measure. It can be calculated in two ways. First, we use 10 percent trimmed mean (trimmed 5 percent from both the tail) to calculate core inflation, then

rescale the weights of remaining component in the consumption basket and take a weighted average to calculate core inflation. In second, we can directly take the weighted average of timed series to calculate core inflation. Wynne (1999) argued that after trimming the series, we can directly take the weighted average, no need to re-scaling the weight as we are focusing on core inflation and weighting system represents the cost of living.

Bryan and Cecchetti (1999) analysed monthly measurement of core inflation in Japan through trimmed mean method. They have used monthly data of Japanese CPI with 88 components starting from the January 1970. In trimmed mean method, they found that 35 percent and 21 percent trimmed are performing well according to RMSE criteria. Again, they examined correlation between money growth and CPI excluding fresh food and energy, and above trimmed mean measure that performed well according to RMSE criteria. As a result, they found that trimmed mean measure is superior to exclusion measure.

Meyler (1999) estimated an alternative measure of core Inflation for Ireland by using limited influence estimator. The author used 1976-1999 Monthly and Quarterly data of Irish HICP. As a result, he found that limited influence estimator of quarterly distribution of price changes results in considerable improvement in root mean square error (RMSE) relative to a benchmark measure of core inflation. This improvement is even larger when monthly data are examined.

Mohanty, Ratha and Ramaiah (2000) used the principle of exclusion and the limited influence approach both trimmed mean and weighted median to estimate core inflation in India. The authors estimate 16 years' monthly data from April 1983 to March 1999 and used Engle Granger Co-Integration test to find best measure to core inflation. Various measures of core inflation must have long run stable relation with headline inflation. The Engle Granger Co-Integration test shows that trimmed mean and weighted mean both are co integrated with WPI headline inflation; where excluded WPI is not co integrated with WPI headline inflation. The Principle of exclusion is not a suitable

measure of core inflation for developing countries, because a large array of commodities shows the relative price volatility over time and hence it would not be appropriate to remove them all from the core measure; and primary commodities have a strong influence on the underlying inflation as they form a sizeable part of household consumption basket. Similarly, Kar (2009) used statistical tools to measure core inflation in India. The author has used WPI inflation for the period of 1982:2 to 2005:12, to construct a better measure of core inflation. A good core estimator of inflation can be defined as efficient, robust, have similar properties with headline inflation or a good predictor of headline inflation. As a result, the author found that the geometric smoothing exponential method of Cogley is the most efficient measure of core inflation which has similar properties as WPI inflation. On the other hand, among limited influence estimators weighted percentile measure gives efficient core series having similar properties with WPI inflation and able to predict at least for certain specific months in regular interval.

Figueiredo (2001) examined five different measures to get the best measure of core inflation for Brazil. He examined exclusion method, symmetric mean, symmetric mean with smoothed series, weighted median and double weighted approach by using monthly data of Brazilian IPCA from January 1996 to May 2000. He tested descriptive statistics and root mean square error to track the trend of all five measures of core inflation and found that 20 percent trimmed mean with smoothed series and double weighted measure perform well than other three measures. Author also tested the correlation between money growth and all five core indicators; and found that double weighted measure performs better than all other four measures. Brischetto and Richards (2006) examined the relative performance of headline CPI, exclusion based core inflation and trimmed mean for Australia, US, Japan and the euro area; and found that trimmed is the best measure which satisfies all the properties of core inflation.

This trimmed mean measure can be calculated of two types; (a) symmetric trimmed mean and (b) asymmetric trimmed mean. In symmetric trimmed mean we trimmed equal percentage from the both tails but in case of asymmetric trimmed mean

we trimmed different percentage according to the presence of skewness and kurtosis present in the series. But, this study is limited to the symmetric trimmed mean measure. We used 25% trimmed mean measure to calculate core inflation and the study covers monthly data of WPI from January 2000 to April 2016 with base year 2004-05.

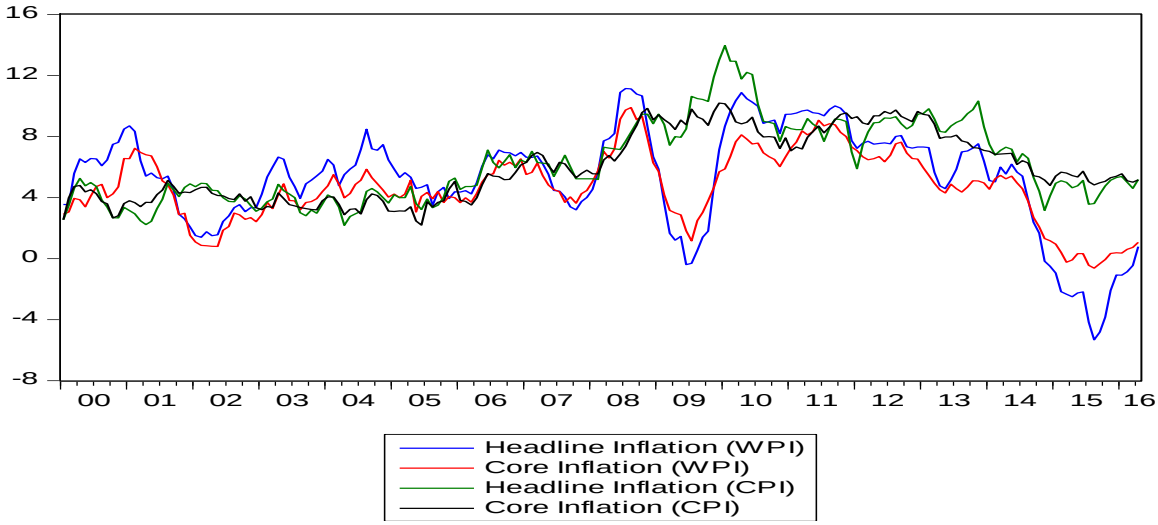


Figure 2.2: **Headline Inflation and Core Inflation (Trimmed Mean)**
Source: Author's Calculation

The above figure 2.2 presents both WPI and CPI inflation and respective core inflation estimated for India by using trimmed mean approach. The trimmed mean core inflation estimated from WPI is comparatively less volatile than exclusion based core inflation estimated from WPI; trimmed mean Core inflation from CPI also performed well.

2.5. Structural VAR Approach (SVAR)

The SVAR measure was developed by Quah and Vahey (1995). According to them core inflation has no impact on real output in the long run. Other than prices core inflation is also affect and affected by other macroeconomic variables. So Quah and Vahey used real GDP to analyse core inflation. They start with a bivariate VAR model; other researchers such as Blix (1995), Folkertsma and Hubrich (2000), Baglino and Morana (2003) expand it to multivariate SVAR model by integrating other macro variables. The assistance of this model is that it is based on monetary theory while its shortcomings are related to the specification and identification of the SVAR model; also it is difficult to understand by

the public. SVAR was developed by Sims (1986) and Bernanke (1986).The standard VAR was developed by Sims in 1980, but it was criticised on the ground that it does not use any economic theory; it only helps in recovering the structural innovations from residuals by using Cholesky decomposition. To overcome from these problems Structural VAR was introduced. The major difference between standard VAR and Structural VAR is the use of economic theory. Structural VAR can be identified from reduced from of VAR model. It is helpful to separate the economically unrelated influences in price index and also useful for forecasting purpose.

Aucremanne and Wouters (1999) analysed both theoretically and empirically the underlying source of movements in inflation for US, Germany and Belgium. They used real business cycle model for an open economy to analyse reaction of optimum monetary policy to different shocks and also used SVAR approach. Their main focus was to find out how monetary authorities should react to different type of shocks and as a result, they found that monetary policy must react to the positive demand shocks and negative supply shocks in same manner as they pass through same channel. Empirically, it is also proved that in all the three countries US, Germany and Belgium positive demand shock has similar effect on prices as by negative supply shock.

Das, John and Singh (2009) analysed twelve different measures of core inflation by using eight different methodologies, i.e., Exclusion basis, Mean-SD, Median, Trimmed Mean, Historical Standard Deviation, Hodrick-Prescott Filter, Wavelet Filter and Structural Vector Auto Regression. They also suggested nine approaches for judging preferred measures based on different properties of core inflation. They found that although exclusion based measures are simple and easy to calculate, it does not satisfy many economic and statistical criteria. The statistical smoothing techniques able to de-noise the inflation series and provide a smooth series of core inflation, but the series are not supported by economic theory. The SVAR based measures based on economic theory of medium to long run neutrality of output, but fails to provide a less volatile series of core inflation.

Goyal and Pujari (2005) used monthly data of both Wholesale Price Index (WPI) and Index of Industrial Production (IIP) to estimate core inflation for India. They used SVAR approach to estimate core inflation by implementing vertical long run supply curve as an identifying condition. This restriction makes core inflation to be output neutral at medium to long run. Other methods for estimating core inflation are not theory based; only SVAR approach is based on the theory of long run vertical Philips curve. After estimating core inflation, they analysed the relationship between headline inflation, core inflation and money supply (M1). They found that core inflation always lies below headline inflation and core inflation granger cause other variables, but none of them granger causes core inflation. This means monetary policy unable to target demand shocks and by responding to temporary supply shocks it leads to a pro cyclical aggravation shocks.

To estimate SVAR measure of core inflation for India, we are using monthly data of Wholesale Price Index (WPI) and Index of Industrial Production (IIP) from April 2004 to January 2014. We are using IIP as a proxy for real output, because monthly data of Gross Domestic Product (GDP) are not available. The data have been collected from the official website of Reserve Bank of India (RBI). To measure core inflation, we are adopting SVAR measure proposed by Quah and Vahey (1995). They defined core inflation does not have any medium to long run impact on output. We are using this definition as long run restriction to identify SVAR. So core inflation or core shock does not have medium to long run impact but non-core shock has. This way we can distinguish between core and non-core shock.

2.5.1. Identification of SVAR

A VAR (p) model can be expressed as:

$$y_t = \mu + A_1 y_{t-1} + \cdots + A_p y_{t-p} + \varepsilon_t \quad (1)$$

$$A(L) y_t = \mu + \varepsilon_t$$

Where A(L) matrix lag polynomial of order p and $\varepsilon_t = N\ (0, \Omega)$.

According to Wold Representation Theorem, under weak regularity conditions, a stationary process can be represented as an invertible distributed lag of serially uncorrelated disturbances. Thus, equation (1) can be written as:

$y_t = A^{-1}(L)\varepsilon_t$

$\Rightarrow y_t = B(L)\varepsilon_t \qquad (B_0 = I)$ (2)

In the above representation, the elements of ε_t are contemporaneously correlated so, they cannot be represented as structural shocks. The elements of ε_t are orthogonalized by imposing restrictions. So, the Wold representation can be written as

$$y_t = C(L)e_t \tag{3}$$

As B_0 is an identity matrix, from equation (2) and (3) we get $\varepsilon_t = C_0 e_t$ and $B_j C_0 = C_j$ so:

$$B(L)C_0 = C(L) \tag{4}$$

In this two variable system the C_0 matrix contains four elements and to orthogonalize the different innovations four restrictions are needed. From the normalization of var(e_t) it follows that:

$$\Omega = C_0 C_0' \tag{5}$$

This imposes three restrictions on the elements of C_0 matrix because of the symmetry of the covariance matrixΩ. One more restriction is needed to identify C_0 i.e. long run restrictions of neutrality. So, the long run expression of equation (3) can be written in matrix form as:

$$\begin{pmatrix} \Delta y_t \\ \Delta p_t \end{pmatrix} = \begin{pmatrix} C_{11}(1) & C_{12}(1) \\ C_{21}(1) & C_{22}(1) \end{pmatrix} \begin{pmatrix} e^{nc} \\ e^{c} \end{pmatrix} \tag{6}$$

Where C(1) = $\sum_{j=0}^{\infty} C_j$ is the long run matrix of D(L). From our restriction$C_{12}(1) = 0$, then C(1) matrix will be lower triangular. Writing the long run expression of equation as$B(1)C_0 = C(1)$, equation (4) and (5) together imply:

$$B(1)\Omega B(1)' = C(1)C(1)' \tag{7}$$

This matrix can be computed from the estimate of Ω and B(1). As C(1) is lower triangular, equation (7) implies that C(1) will be the unique lower triangular choleski factor of $B(1)\Omega B(1)'$. Let M denote the lower triangular choleski decomposition of (7), then C_0 can be easily obtained from:

$$C_0 = B(1)^{-1}M \tag{8}$$

By identifyingC_0, the systems structural shocks and their dynamics in equation (3) can be found.

2.5.2. Result of SVAR Measure of Core Inflation

The IIP is seasonally affected, so first by using exponential smoothing seasonal effects are removed from IIP series. Then we have tested the stationary by using both Philips Peron (PP) test and Augmented Dickey Fuller (ADF) test and both the series are stationary at first difference, i.e., I(1). We have also taken the log value of each variable to reduce the variation. Then we tested co-integration and found that the variables are not co-integrated. By using lag length criteria, we have chosen second lag for analysis. The VAR model also satisfies other criteria, like no serial correlation, no heteroskedasticity and also normality of residuals. Core shock represents the demand shock while non-core shock represents the supply shock. From the impulse response function, we get that reaction to non-core shock is more volatile than response to core shock and also core shock neutralise faster than non-core shock.

Table 2.2
Result of Unit Root Test (ADF Test without Trend)

Variables	t-statistics	P Value
At Level		
Wholesale Price Index	-2.82	0.06
Consumer Price index	-2.09	0.24
Seasonally adjusted IIP	-2.74	0.07
First Difference		
Wholesale Price Index	-7.62	0.00*
Consumer Price index	-11.91	0.00*
Seasonally adjusted IIP	-22.82	0.00*

Note: indicates the tabulated value at 5% level of significance i.e. -3.42.*
Source: Author's Calculation

The above table 2.2 presents the result of unit root test of Augmented Dickey Fuller (ADF) without trend of the variables WPI, CPI and seasonally adjusted IIP. All the variables are non-stationary at the leveli.e. we cannot reject the null hypothesis of presence of unit root. Then we converted all the variables to first difference and found all the variables are stationary at first difference and integrated of order one, i.e., I (1) process and now we can reject the null hypothesis of presence of unit root.

Table 2.3
Result of Johansen Co-Integration Test

Hypothesized No. of CE(s)	Eigen value	Max-Eigen Statistic	0.05 Critical Value	Prob.**
IIP and Headline WPI				
None	0.053368	10.58514	14.26460	0.1763
At most 1	0.044370	8.759171	3.841466	0.0031
IIP and Headline CPI				
None	0.033165	6.509452	14.26460	0.5487
At most 1	0.018104	3.526166	3.841466	0.0604

Notes: 1. Null hypothesis indicates no co integration at the 0.05 level.
*2. *denotes rejection of the hypothesis at the 0.05 level.*
Source: Author's Calculation

The above table 2.3 presents the result of Johansen co-integration test of the variables. The result shows that there is no co-integrating relationship exists between variables, that means variables does not have any long run relationship. As there is co-integrating relationship exists between variables, we go for VAR analysis. Then by using long run restriction according to our core inflation definition and estimated SVAR core inflation.

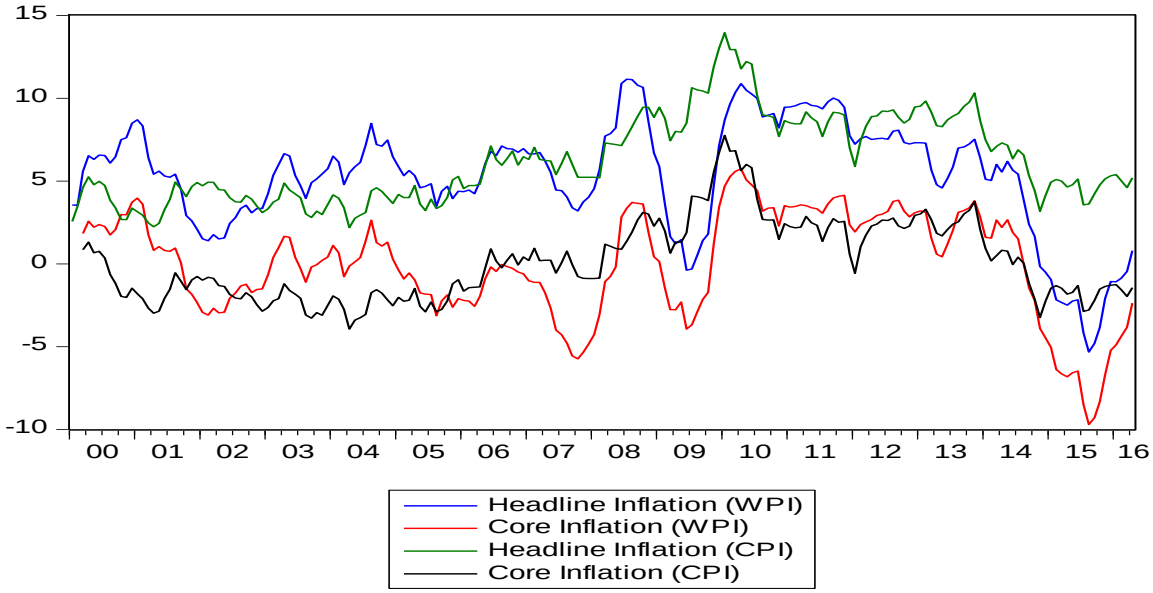


Figure 2.3: **Headline Inflation and Core Inflation (SVAR Measure)**
Source: Author's Calculation

The above figure 2.3 presents the core inflation estimated by SVAR method. Core inflation estimated from this method shows a huge difference between headline and core inflation. As per the definition of core inflation, in the long run core inflation and headline must follow the same path but it does not show any such type of relation between headline and core inflation estimated by using SVAR method.

2.6. Comparison of Exclusion Measure, Trimmed Mean Approach and SVAR Approach

All the measures of core inflation suggest that monetary policy must focus on core inflation rather than headline inflation, because headline inflation includes temporary supply shocks, i.e., non-core shock. But, the question arises which method to measure of core inflation is good one, whether Trimmed mean measure, exclusion measure or SVAR measure is appropriate. Earlier we have already discussed that mostly commonly used exclusion method to measure core inflation is not appropriate one. If we analyse the proper economic interpretation, then SVAR is the appropriate measure to estimate core inflation, because this measure is based on the proper definition of core inflation; and it is exactly showing how output and inflation are reacting to core or non-core shock. It also gives the variance decomposition of both shocks and we are able to know how exactly core and non-core shock is fluctuating. But, in case of trimmed mean measure, we are not getting any of the above mentioned information about shocks in the economy. We are simply excluding some percentage of outlier data from the series; by following this way we are losing much information about the series. In exclusion method, we are directly ignoring some commodities considering them as volatile, but those commodities are not volatile all the time. In this case, SVAR is better measure than trimmed mean and exclusion measure, but it is very complicated to calculate and to explain to the public. If monetary authorities are interested to maintain transparency to the public, then it must use trimmed mean or exclusion method instead of SVAR method. Form the table 2.4 of summary statistics, we find that trimmed mean CPI has the lowest standard deviation.

Table 2.4
Summary Statistics of the Different Measures

Variable	Mean	S.D
Headline (WPI)	5.30	3.36
Exclusion Measure (WPI)	3.73	2.58
Trimmed Mean (WPI)	4.68	2.30
SVAR (WPI)	-0.03	3.18
Headline (CPI)	6.25	2.58
Exclusion Measure (CPI)	5.88	2.38
Trimmed Mean (CPI)	6.02	2.21
SVAR (CPI)	0.12	2.39

Source: Author's Calculation

2.7. Dynamic Relationship between Headline and Core Inflation

Headline inflation represents the general price level and core inflation represents inflation after extracting transitory movements from general price level. For measuring core inflation several measures are there and all the measures are broadly categorise into statistical measures and model based measure. Model based measures are difficult to calculate and too communicate with public, while statistical measures are easy to calculate and also to communicate with public. The problem is that model based measure is more appropriate then statistical measures, still every central banks prefer statistical measure to maintain the transparency of monetary policy. Core inflation represents the long run trend of the inflation and in the long run average rate of core inflation must be equal to average rate of headline inflation. But, as headline inflation consists of temporary fluctuations of price of some commodities, it diverges from core inflation in short run. In the long run again it comes back to underlying trend of the inflation. Now the question arises who adjust to whom? Core inflation adjusts with headline inflation or headline inflation adjusts with core inflation or both adjust. And, what is the speed of adjustment between them. According to the definition of core inflation, it must act as a driver and headline inflation must move along with; any divergence must be adjusted by headline inflation.

When we are considering core inflation as a measure of price stability, we are trying to ignore mostly flexible prices and consider sticky prices which can well represent the underlying trend of the price level. Generally, headline inflation consists of large portion of flexible prices, which varies frequently and core inflation consists of mostly sticky prices, so headline inflation mostly affected by supply shocks. According to New Neoclassical Synthesis[5], monetary policy must operate by considering sticky prices, because it helps the economy to get close to the theoretical flexible equilibrium price. Other than stabilising prices, monetary policies also focus on stabilising output and employment, in that case New Neoclassical Synthesis suggest to focuses on core inflation rather than headline inflation. As core inflation consists of sticky prices it doesn't fluctuate much, and as headline inflation consists of flexible prices it frequently deviates from target path of inflation, so headline inflation must adjust with core inflation. Most of the studies worry about the appropriate measure of core inflation; whether headline should be targeted or core inflation. There are few studies which exactly focus on the direction and speed of adjustment between headline and core inflation. Some of them are discussed below.

Raj and Misra (2011) computed six different exclusion based measures and then examine core inflation properties of all the six core inflation measures. They also try to find out whether there is any causal relationship exists between headline and core inflation. They try to prove that there must be one-way causal relationship exists between headline and core inflation, i.e., from headline to core, not *vice versa*. Headline inflation should converge to core inflation no other way. Gamber, Smith and Eftimoiu (2011) also measured the dynamic relationship between headline and core inflation for US. They used CPI and PCE less food and energy, median CPI, the trimmed mean CPI and the trimmed mean PCE as core inflation measures with structural breaks to analyse the dynamic relationship between headline and core inflation. As a result, they found that the adjustment process between headline and core inflation is different for different monetary regime, but an optimal trimming can be underlying inflation, independent of

[5]New Neoclassical Synthesis is the combination of both new classical and new Keynesian school of thoughts. Goodfriend and King categorized the main theme of new neoclassical synthesis in to four elements; i.e. (a) intertemporal optimization (b) rational expectations (c) imperfect competitions and (d) relative price adjustment.

the monetary regime. Mehra and Reilly (2009) also did the similar type of studies by taking CPI less food and energy as the measure of core inflation and also conclude the same result that monetary policy affects the adjustment process between headline and core inflation. When monetary policy is accommodative, the gap is adjusted by core inflation and if it is not then the gap is adjusted by headline inflation.

Quah and Vahey (1995) measured core inflation for UK. They also mentioned about the problem of how quickly economic agents adjust to core inflation. Because according to traditional Keynesian view, due to nominal rigidities adjustment process will be slow. A similar study has been done by Martel (2008). The author used structural VAR approach to measure core inflation for Canada. As a result, they found that core shocks are the key driver of headline inflation. They also found that in many periods headline inflation tracks core inflation poorly. Mishkin (2007) tried to find out changes in inflation dynamics. According to author before analysing changes in inflation dynamics, first we need to know how long the effectsof any shock to inflation last. Any shock to inflation remains for a long period or after short period it revert backs to its initial level. Roger (1998) described the different concepts, uses and measurement of core inflation. While explaining the concepts of core inflation, he suggests that when price level deviates from its target path before any central bank actions, it is must necessary to know whether the deviations is the result of supply disturbance or not. Also, it is important for a policy to know how quickly the deviations of price level adjust regardless the cause of deviation. In these circumstances, the most useful measure of core inflation would be the difference between ex-ante transient and permanent changes in aggregate price level.

Lee, Lee and Kim (2013) examined an alternative measure of core inflation which has a strong correlation with headline inflation because even though monetary authorities try to stabilise the headline inflation by controlling a target variable, i.e. core inflation, leverage will be weakened due to low correlation between the two inflation rates. Bodenstein, Erceg and Guerrieri (2007) marked the divergence between headline and core inflation due to substantial energy price hikes.

2.7.1. Causal Relationship between Headline and Core Inflation

First of all, we try to know the causal relationship between headline and core inflation. Core inflation represents the underlying trend of the inflation and headline get fluctuate due to temporary fluctuations, so headline must adjust towards core inflation if there is any diverge from equilibrium path. Core should cause headline inflation not *vice versa*. In case of granger causality, if one variable causing another variable that means past values of first variable has more information regarding prediction of second variable than past values of second variable itself. Therefore, core inflation must granger cause headline inflation not *vice versa*. In the following table 2.5 we present the result of granger causality test.

Table 2.5
Result of Granger Causality Test

Inflation Measures	Headline does not granger cause core		Core does not granger cause headline	
	F Statistics	P Value	F Statistics	P Value
Ex_Core Inflation (WPI)	8.36	0.00*	4.43	0.01*
Trim_Core Inflation (WPI)	10.37	0.00*	0.25	0.77
SVAR_Core Inflation (WPI)	0.01	0.98	0.75	0.47
Ex_Core Inflation (CPI)	6.80	0.00*	2.71	0.06
Trim_Core Inflation (CPI)	2.68	0.07	4.46	0.01*
SVAR_Core Inflation (CPI)	1.74	0.17	1.73	0.17

Notes: Lag length 2 was chosen according to SIC criteria.
**Indicates 5% level of significance.*
Source: Author's Calculation

From the above table 2.5 of granger causality result we find that, in case of ex_core(WPI) inflation both headline and core inflation causing each other; and in case of ex_core (CPI) inflation, headline inflation granger causing core inflation, but core inflation does not granger cause headline inflation. In case of SVAR, core inflation (both WPI and CPI), neither headline inflation granger because of core inflation nor core inflation granger cause headline inflation. Trim core (WPI) inflation does not granger cause headline WPI inflation, but headline WPI inflation granger cause trim core (WPI) inflation; while trim core CPI inflation granger cause CPI headline inflation, but CPI headline inflation does not granger cause trim core CPI inflation. From the above discussion, it is clear that only trim core CPI inflation performs better holds the definition and properties of core inflation.

2.7.2. Dynamic Relationship between Headline and Core Inflation: VECM Analysis

As we know headline inflation consists of temporary short term fluctuations, and we get core inflation after excluding these short term fluctuations from core inflation. Core inflation represents the underlying trend of the core inflation and does not affect output in the medium to long term. In general, we can say that in the long run core and headline inflation follow the same trend. As we have already mentioned earlier and we have found existence of co-integrating relationship exist between headline and core, we use VECM model. In all the cases headline and trimmed mean inflation, headline and ex_core inflation, and headline and SVAR inflation we get one co-integrating vector. Through VECM model, we are trying to find out the long run adjusting process between headline and core inflation. VECM representation is:

$$\Delta H_t = \alpha_1 + \gamma_1[H_{t-1} - C_{t-1}] + \sum \beta_{ij} \Delta H_{t-j} + \sum \lambda_{ij} \Delta C_{t-j} + e_{1t}$$

$$\Delta C_t = \alpha_2 + \gamma_2[H_{t-1} - C_{t-1}] + \sum \beta_{ij} \Delta H_{t-j} + \sum \lambda_{ij} \Delta C_{t-j} + e_{2t}$$

As it is already mentioned earlier that headline inflation must adjust with core inflation. If headline inflation is above core inflation, it must fall down; if it is below, it must rise. If there is any deviation from the equilibrium, then adjustment must be done by headline inflation. When we look for the dynamic relationship between headline inflation trimmed mean inflation, major adjustment is done by headline inflation.

Table 2.6
Unit Root Test Result (ADF Test without Trend)

Variables	t-statistics	P Value
At Level		
Headline Inflation (WPI)	-2.82	0.06
Ex_Core Inflation (WPI)	-2.87	0.06
Trim_Core Inflation (WPI)	-2.62	0.08
SVAR_Core Inflation (WPI)	-2.94	0.08
Headline Inflation (CPI)	-2.09	0.24
Ex_Core Inflation (CPI)	-2.43	0.13
Trim_Core Inflation (CPI)	-1.83	0.36
SVAR_Core Inflation (CPI)	-2.26	0.18
First Difference		
Headline Inflation (WPI)	-7.62	0.00*
Ex_Core Inflation (WPI)	-5.95	0.00*
Trim_Core Inflation (WPI)	-5.40	0.00*

SVAR_Core Inflation (WPI)	-8.73	0.00*
Headline Inflation (CPI)	-11.91	0.00*
Ex_Core Inflation (CPI)	-16.07	0.00*
Trim_Core Inflation (CPI)	-13.60	0.00*
SVAR_Core Inflation (CPI)	-11.91	0.00*

*Note: * indicates the tabulated value at 5% level of significance i.e. -3.42.*
Source: Author's Calculation

The above table 2.6 presents the result of the unit root test ADF without trend of the both headline WPI and CPI inflation and all six different measures of core inflation. All the variables are non-stationary at the level i.e. we cannot reject the null hypothesis of presence of unit root. Then we converted all the variables to first difference and found all the variables are stationary at first difference and integrated of order one, i.e., I (1) process and now we can reject the null hypothesis of presence of unit root.

Table 2.7
Adjustment Coefficients among Headline and Core Inflation

Adjustment between Headline (WPI) and Ex_Core (WPI) Inflation	
Headline Inflation	Ex-Core
-0.05(0.01)*	-0.01 (0.01)*
Adjustment between Headline (WPI) and Trim_Core (WPI) Inflation	
Headline Inflation	Trim-Core
-0.07(0.05)*	-0.07(0.03)*
Adjustment between Headline (WPI) and SVAR_Core (WPI) Inflation	
Headline Inflation	SVAR-Core
-0.02(0.00)*	-0.02(0.00)*
Adjustment between Headline (CPI) and Ex_Core (CPI) Inflation	
Headline Inflation	Ex_Core
0.00(0.03)*	0.12(0.04)*
Adjustment between Headline (CPI) and Trim_Core (CPI) Inflation	
Headline Inflation	Trim-Core
-0.16(0.05)*	-0.01(0.03)*
Adjustment between Headline (CPI) and Trim_Core (CPI) Inflation	
Headline Inflation	SVAR-Core
-0.01(0.11)	0.03(0.11)

. *Note: *The tabulated value at 5% level of significance i.e. -3.42.*
Source: Author's Calculation

The above table 2.7 presents the dynamic relationship between WPI and CPI headline inflation with six different measures of core inflation. According to the definition and properties of core inflation, any divergence between headline and core inflation must be majorly adjusted by headline inflation. Core inflation must act as a

driver and headline inflation must move along with it. In case of WPI headline and WPI core (all three measure i.e. exclusion, trimmed mean and SVAR measure) inflation; any divergence between them, neither headline inflation nor core inflation significantly make adjustment. CPI headline and CPI core inflation (SVAR measure) also performed same as WPI headline and core inflation. In case of ex_core CPI and Headline CPI inflation, adjustment from the side of headline CPI inflation Zero and ex_core adjust around 12 percent in every period. The only core inflation measure that holds the definition and properties of core inflation, core inflation act as a driver and headline inflation move along with it, is trim_core CPI inflation. Any divergence between headline and (trim_core CPI) core inflation, majority of adjustment is done by headline CPI inflation, i.e., around 16 percent and only 1 percent adjustment is done by trim_core CPI inflation.

2.8. Conclusion

It is always questionable whether monetary policy focus on core inflation or headline inflation. If it focuses on core inflation, it can avoid the problem of reacting to temporary fluctuations in the economy which can permanently affect the economy, but the main goal of monetary policy is to control overall inflation. From our empirical analysis we can suggest that monetary policy must focus on core inflation. Both the core measures are performing well than headline inflation. Now the question arises that among both the measures which one is to follow. In terms of proper economic interpretation, model based approach is more appropriate than statistical approach. However, it is difficult to find out the proper restriction to identify Structural VAR and also difficult to communicate with public. In structural VAR we estimate core inflation according to its proper definition, while in case of statistical approach there is no proper logic behind excluding commodities from the index; but it is easy to calculate, to communicate with public and maintain transparency. Therefore, we can suggest SVAR is a good measure to estimate core inflation, but practically using it is difficult. But, if we will see practical applicability of the measures, then trimmed mean measure is better one. This study also finds that the trimmed mean measure is performing better than the other two measures of core inflation. This study compares the performance of core inflation estimated from both the WPI and combined CPI, but the result shows that trimmed mean measure of

core inflation estimated from combined CPI outperform than trimmed mean measure of core inflation estimated from WPI inflation.

While analysing the dynamic relationship between headline and core inflation, our result supports the findings of the previous studies that the speed and direction of adjustment between headline and core inflation depends on the different monetary regime. Any unexpected changes in the monetary policy affect consumer behaviour and also price level before consumers start considering rational expectation. In case of India, we see that trimmed mean measure is giving better result than non-food manufacturing product measure and also holding the definition of core inflation. Even Gamber, Smith and Eftimoiu also got the same result. But, as per the definition of core inflation that headline inflation should adjust with core inflation trimmed mean measure of core inflation estimated from combined CPI performs well and maximum adjustment is done by headline inflation than core inflation.

Chapter 3

Domestic and Imported Core Inflation in India

3.1.Introduction

Inflation targeting, being a popular monetary policy framework, aims to maintain a stable price level in an economy and does not allow an economy vulnerable to a speculative attack. When we talk about a closed economy being committed to inflation targeting by central banks is correct. But, when it comes to an open economy, fully committed to inflation targeting is not a correct decision. In an open economy, it's not a wise decision to blindly exclude volatile commodities from consumption basket and calculate inflation to maintain price stability in the economy, because a consumption basket consists of both tradable and non-tradable goods. Non-tradable goods represent domestic demand and supply condition of consumer goods, while tradable goods represent the changes due to movements in exchange rates and international price of goods and services. Hence, fluctuations or vulnerability in general price level of an economy is not only because of supply side problem which we intend to exclude from headline inflation (estimating core inflation) and then conduct monetary policy; external factors like changes in the international price of various commodities also affect the domestic price of an economy through tradable goods and services.

In inflation targeting, it always shows a commitment to intervene in the foreign exchange market to defend that target. Any changes in exchange rate deviates the level of inflation from its target. According to the traditional theory, currency depreciation leads to improve the external sector of the economy by decreasing import. In this situation, import becomes costlier; so it discourages import and encourages export. But, in flexible exchange rate regime, depreciation of currency is automatically adjusted according to the demand and supply of the currency under free market mechanism.

Sometimes, currency depreciation leads to inflation in the economy. Both can be corrected by targeting interest rate. But, sometimes, it works in reverse way; demand for imported goods like gold and oil don't decrease, which makes the condition of home currency worsen. So, depreciation of currency leads to increase in the general price level directly or indirectly. According to Stockman (2004), depreciation of currency contributes to increase in general price level only in developing countries. In developed countries, share of imported goods in their consumption basket is limited, so it doesn't affect inflation. To prove this, he examined the situation of US and found that dollar depreciation neither causes inflation nor it helps in predicting future rate of inflation, although he considered only direct effect of currency depreciation.

Core inflation represents the long run trend in the price level by excluding temporary fluctuations. Temporary fluctuations mean it excludes supply side shocks which are not in the control of monetary policies. Currency depreciation also can affect the economy both as demand shock and supply shock. According to Ito (2007), if export and domestic price of an economy increases in reaction to currency depreciation then currency depreciation is a sign of demand shock; and if export decreases and domestic price increases then currency depreciation is a sign of supply shock. Some studies tried to distinguish imported shocks from other shocks of the economy. Bjornland (2001) identified domestic and imported core inflation for Norway. To identify imported core inflation, he used oil price shock and foreign price shock and as a result he found that adverse oil price shocks are important reason behind the overvaluation of CPI inflation relative to domestic core inflation in the late 1970s and early 1980s. A similar study has been conducted by Goyal and Singh (2006). They found that the impact of oil price shocks in the context of Indian economy. They examined the impact of oil price shock for both horizontal and vertical supply curve. First, they distinguished oil price shock from normal supply shock and then estimated its impact on inflation and output. As a result, they found that the structure of Indian administrated prices delayed the impact of dollar oil price shock, but over time resulted in cumulative inflation higher than mandated by international oil shock, at high output cost. They also marked that domestic

oil price never falls; reform in Indian oil market should allow prices to fall as well as rise.

Rise in oil price leads to an inflationary shock in the economy through two different channels. In the first round, it directly affects the price of energy products and indirectly affects the energy related to cost of production of other goods and services. In second round, increase in the cost of living leads to a demand for increase in wage among worker to maintain their real income. Generally, any external shocks affect an economy through four channels, i.e., terms of trade effect, higher cost of production, inflationary effect, and financial effect and finally, through psychological effect. But in present study our main focus is to explore the channel of inflationary effect of external shocks to the economy.

As oil price affects the general level of inflation as an imported factor, currency devaluation also acts the same. The direct channel for transmission of currency depreciation to inflation is the prices of imported final and intermediate goods. Some disturbances like foreign exchange risk premium, foreign interest rate, and foreign inflation can affect the general price level of the country through exchange rate disturbances. Currency depreciation can lead to a higher price level and it can lead to redistribution of income from people with low marginal propensity of save to people with high marginal propensity of save; and ultimately leads to decrease in aggregate demand and output. Currency depreciation can also lead to the situation of recession, if the price elasticises of imports and exports are low. So, instead of taking oil price shock as imported factor affecting core inflation we are taking normal exchange rate to show how currency devaluation can affect the core inflation.

In this chapter, we try to identify how external shocks affect Indian inflation. But as main purpose our study is to find the perfect measure core inflation for India. Therefore, instead of directly looking into how external shocks affect Indian inflation, first we will see how CPI headline inflation itself attracts inflation from external shocks. Many goods from CPI consumption basket are highly associated with external shocks,

which lead to rise in inflation level. So, here the question arises how to deal with these problems while targeting inflation? First, we estimate purely domestic inflation which is not affected by external shocks; this domestic inflation can be followed while conducting monetary policy. Second, we try to find out how external shocks affect the Indian inflation?

3.2. India and its External Sector

India getsmore open up to the world economy after the implementation of New Economic Policy (Privatisation, Liberalisation and Globalisation) in 1991. India's external sector grows rapidly after this and situation of balance of payment become stronger, which was one of the major reasons behind adopting New Economic Policy. External sector plays crucial role in economic expansion of a country. It includes some critical issues, such as the exchange rate policy, capital flows, appropriate level of current account balance and foreign trade.

External Sector: An important positive outcome in 2015 is the modest pickup in the growth of some of the advanced economies. However, growth in emerging market and developing economies declined for the fifth consecutive year. As a result, overall global economic activity remained subdued in 2015. The IMF projected growth in the global economy to improve from 3.1 per cent in 2015, to 3.4 per cent in 2016 and further to 3.6 per cent in 2017. Growth in advanced economies is projected at 2.1 per cent in 2016 and to continue through 2017 at the same rate (World Economic Outlook, 2016).

The slowdown and rebalancing of the Chinese economy, lower commodity prices, and strains in some large Emerging Market and Developing Economies (EMDE) are likely to continue to weigh on their growth prospects in 2016–17. Assessments indicate that mixed inflation developments in the EMDEs reflect the conflicting implications of weak domestic demand and lower commodity prices versus marked currency depreciations over the past year. The WEO Update also indicates that India and the rest of emerging Asia are bright spots, with some other countries facing strong

headwinds from China's economic rebalancing and global manufacturing weakness. World trade volume growth projections have been placed at 2.6 per cent and 3.4 per cent respectively for 2015 and 2016, which is much lower than what was estimated earlier in WEO in October 2015.

Foreign Exchange Reserves: India's foreign exchange reserves at US$351.5 billion as on 5 February 2016 mainly comprised of foreign currency assets amounting to US$328.4 billion, accounting for about 93.4 per cent of the total. With an increase in reserves in 2015-16, all traditional reserve-based external sector vulnerability indicators, namely foreign exchange cover for imports and short-term debt, have improved.

Exchange Rate: During 2015-16 (April-January), the average exchange rate of the rupee depreciated to R65.04 per US dollar as compared to R60.92 per US dollar in 2014-15 (April-January). This was mainly on account of the fact that the dollar strengthened against all the major currencies because of stronger growth in the USA as well as the fact that China's growth and currency developments this year deteriorated, impacting the outlook on other EDMEs owing to risk-aversion perceptions of global investors. It is, however, instructive to note that in 2015-16 so far, the rupee has performed better than the currencies of most of other EDMEs (except the Chinese yuan).

External Debt: India's external debt stock increased by US$8.0 billion (1.7 per cent) to US$483.2 billion at end-September 2015 over end-March 2015 as per the latest available data. This rise in external debt occurred on the account of long-term debt, particularly commercial borrowings and NRI deposits. However, on a sequential basis, total external debt at end-September 2015 declined by US$291 million from the end-June 2015 level. The maturity pattern of India's external debt shows the predominance of long-term borrowings. At the end-September 2015, long-term debt accounted for 82.2 per cent of India's total external debt, vis-à-vis 82.0 per cent at end March 2015. Correspondingly, the proportion of short-term debt declined. India's external debt has remained in safe limits, with an external debt to GDP ratio of 23.7 per cent and a debt service ratio of 7.5 per cent in 2014-15. 1.64 India's foreign exchange reserves provided a cover of 72.5

percent to total external debt stock at end-September 2015 vis-à-vis 71.9 per cent at end-March 2015. The ratio of short-term external debt to foreign exchange reserves was 24.6 per cent at end September 2015 as compared to 25.0 per cent at end-March 2015. The ratio of short term debt to total external debt decreased steadily and stood at 17.8 per cent at end-September 2015 as against 18.0 per cent at end-March 2015.

The Indian economies have made substantial improvements in its macroeconomic fundamentals and impressive strides in reducing macro-vulnerability with reforms in key areas, pursuit of fiscal prudence and consolidation, focus on price stability and the resultant benign price situation and comfortable level of external current account. With improved industrial growth supplementing the buoyant services sector, overall economic growth has also picked up. Set against the background of the unsupportive global economic landscape, and back-to-back weak monsoons with deleterious effects on farm production, the growth rate of 7.6 per cent in 2015-16 as estimated by the CSO is encouraging. In sharp contrast, the global economy, shrouded in uncertainties and constrained by sluggish demand, has failed to generate confidence. While the emerging market economies have clearly slowed down, the large Chinese economy is faced with concerns of rebalancing investment and consumption activities. In this milieu, the Indian economy stands out as a haven of macroeconomic stability, resilience and optimism; and can be expected to register GDP growth that could be in the range of 7.0 to 7.75 per cent in the coming year.

With focus on reforms in key sectors coupled with stable macroeconomic conditions, the above growth prospect for the economy in the next year appears reasonable. Yet, the outlook will be conditioned by a 22 Economic Survey 2015-16 number of factors; some of which indicate downside risks; the strongest of them being weak global demand. In 2015-16, the external vulnerability indicators improved and the rupee weathered the depreciation pressure better than the currencies of most emerging market economies. The headwinds to growth may come from sluggish global demand as the Indian economy is closely integrated with the rest of the world; exports and imports together constitute 42 per cent of the GDP, even at the reduced levels in 2015-16. On the

brighter side, however, the composite growth of India's trading partners is projected to modestly improve in 2016. Improved competitiveness and brighter perceptions about the Indian economy get reflected in greater investment inflows.From the angle of aggregate demand, domestic absorption has remained reasonably strong, despite reduction in overall investment. Private consumption has, of late, been the major driver of growth. The possible shifts on the consumption front in the next year are: first, consumption incentives flowing from declining oil prices may partially recede in the next year; second, the pay commission awards could potentially add modestly to consumption demand; third, an improved farm sector performance can add to rural consumption. However, it may be hard to endlessly expect significantly higher growth impetus from consumption. Government's focus on fiscal consolidation rightly limits the option of raising general government consumption expenditure. Private corporate savings and investment showed encouraging results in 2014-15, but the eventual outcome may also be influenced by indications of excess capacity in some sectors. However, with multifaceted measures from the government to foster industry and enterprise, investment-led growth should return.To encapsulate, in the short run, Indian growth may fall short of its growth potential of 8-9 per cent.

3.3. Review of Literature

In this section, we have discussed both theoretical and empirical literature. Few of them are discussed below. Kirker (2010)used an over-identified dynamic factor model to identify tradable and non-tradable factors behind driving core inflation of New Zealand and Australia. The results show that in both the countries non-tradable factors are main reasons behind inflation. Price (2013) also tried to find out the sectoral factors (tradable and non-tradable) behind driving core inflation of New Zealand and found similar result as Kirker (2010), i.e., core inflation is mostly driven by non-tradable factors.

Dixon, Franklin, and Millard (2014) discussed whether monetary policy should react to relative price shocks or not. The study empirically tested both the situation when interest rate responds to sectoral inflation and when it responds to aggregate inflation.

Optimal monetary policy rule performs better when it responds to sectoral inflation than focusing only on aggregate inflation.

Reis and Watson (2010) tried to answer two questions related to relative good's price and inflation. First, volatility share of inflation associated with each component of price index and their relation to conventional measures of monetary policy and relative price shock and finally, what drives the Phillips correlation between inflation and measures of real activity? To answer these questions, the study decomposed sectoral good's price into three components: (a) pure inflation (b) an aggregate relative price index and (c) idiosyncratic relative prices. After empirical analysis the study finds that pure inflation is smoother and less volatile than other two components.

Kumhof, Li and Yan (2007) proposed a general framework to examine the vulnerability of different monetary regimes to speculative attacks. The study finds that it is quite common to experience speculative attack under inflation targeting regime and chance of speculative attack is relatively higher under CPI inflation targeting than under domestic inflation targeting because of the large share of tradable goods in the aggregate consumption basket.

Batini and Tereanu (2009) found a solution for inflation targeting countries when oil prices rise and drop fast. The study uses a small open economy DSGE model to design the correct monetary policy to handle the above mentioned situation. As a result, the study finds that it takes time to restraint the magnitude of a shock and years to restraint at minimum output gap variability costs consecutive shocks of the same magnitude. A loss in target credibility, dramatically worsen the policy dilemma. Results also suggest that reacting more aggressively to the shock reduces output variability costs of the disinflation. This failure by many central banks to act promptly during theshocks explains the subsequent difficulties experienced by many in containing an increasing up of inflation expectations. Second, the central bank communication is crucial at the time when target misses. Explaining the central bank's strategy on how it will return inflation

to target and over which horizon; with possible updates in case of repeated shocks; fully and transparently, may have real benefits by minimizing target disbelief.

Minella, Freitas, Goldfajn and Muinhos (2003) analysed how central bank of Brazil manages its inflation targeting objective in the period of exchange rate volatility. The main problem every central bank faces in this situation is the problem of credibility. The intensity and magnitude of the shocks that hit the Brazilian economy in 2001 and 2002, the cost in terms of output losses of a policy aimed at completely offsetting these shocks in a short period of time and keeping inflation within the tolerance intervals would have been significantly higher. The Brazilian experience has been a successful stress test for the inflation targeting framework.

Svensson (1998) explained the features of inflation targeting regime in an open economy. The study first examines the properties of strict vs flexible inflation targeting and domestic vs CPI inflation targeting relating them to properties of Taylor rule: flexible inflation targeting, effectively compared to strict inflation targeting, and induces less variability in variables other than inflation, by effectively targeting inflation at a longer horizon. Flexible CPI-inflation targeting, compared to both strict CPI-inflation targeting and flexible domestic inflation targeting, results in considerable stabilization of the real exchange rate while CPI-inflation targeting deviates conspicuously from the Taylor rule, due to its implicit concern about real exchange rate depreciation.

Parker (2014) found the impact of exchange rate movements on consumption of imported goods. The CPI import share is consisting of around 15% of direct import and 10% of indirect import. The import share of tradable CPI is much higher than non-tradable firms. Jacobs and Williams (2014) found the determinants of non-tradable inflation. The non-tradable inflation also determined the spare capacity in production and labour market of a domestic economy. Coleman (2007) compared both the tradable and non-tradable inflation of Australia and New Zealand. The relative price movements of Australia and New Zealand are highly correlated. Non-tradable sectors are the main reason of inflation in both the countries.

Mallick (2004) examine the different determinants of India's trade and inflation. The study finds that trade balance effects of tight credit policy are more enduring than that of devaluation. Devaluation actually worsens trade balance and hence devaluation cannot be an option in response to negative trade shock.

3.4. Data and Methodology of the Study

The main aim of this study is to find out how different goods in consumption basket themselves attract external shocks and lead to rise in inflation level. Tradable good in the consumption basket are highly associated with external shocks and changes in these goods lead to raise in general price level. While conducting monetary policy, monetary authorities must follow tradable inflation and to achieve its objective of inflation targeting monetary authorities must follow purely domestic inflation i.e. non-tradable inflation of the economy. Hence, first we estimate tradable and non-tradable inflation for the economy by separating different goods and services from the consumption basket. The traditional and rule of thumb method to classify items under CPI into tradable and non-tradable goods is categorising all goods/manufacturing goods/industry as tradable goods and services as non-tradable goods. But this is not an appropriate method to classify tradable and non-tradable goods; because now day services are also tradable like tourism, and information and communication technology; and these two items are not a part of CPI combined index of India. The proper method for identifying tradable and non- tradable good is to find out the goods which are actually traded i.e. the goods which are exported and imported via the source: the international trade statistics, (Goldstein and Officer, 1979). The other method to identify tradable and non-tradable good is to identify whether the good or industry is export oriented or import oriented from input-output table of each industry. This is to identify the significance of the international trade in each industry. An arbitrarily determined threshold is then used to categories the commodity or industry group as tradable and non-tradable, (Dwyer (1992); Gregorio et al. (1994)).

However, our study is limited to traditional method of dividing commodities of CPI index into tradable and non-tradable goods. Initially India was following WPI as its index of inflation, which hardly includes any non-tradable or service sector in its basket. In 2014 it shifts its index from WPI to CPI, and it includes non-tradable goods and service in its basket; but it has only 19 data points which is not sufficiently long for statistically robust analysis. Inflation of service sector and non-tradable goods in India is playing a major role; the main reason behind the divergence between WPI and CPI is the presence of service sector in CPI index. After estimating tradable and non-tradable inflation for India, we use Vector Auto Regression (VAR) model to identify exact inflation of India's react to any movements of exchange rate and oil price.

3.4.1. Vector Auto Regression (VAR)

To examine the dynamic relationship between exchange rate, oil price, tradable and non-tradable inflation with macroeconomic variable, a vector auto regression model (VAR) is employed. This approach has two major advantages over the extent of empirical research on this issue. First, VAR superficially resembles simultaneous equation modelling in that all the variables are considered to be endogenous. However, each endogenous variable is explained by its lagged or past values and lagged values of the other endogenous variables included in the model. Usually there are no exogenous variable in the model. Thus, by avoiding the imposition of a priori restriction on the model the VAR adds significantly to the flexibility of the model. Second, the VAR methodology can accommodate general dynamic relationship among economic variables. Because most of the relevant empirical analyses utilize a partial equilibrium framework and do not account fully for dynamic interrelations; and previous studies relating this topic may yield misleading inferences.

A natural starting place for multivariate models is treating each variable symmetrically. In a two variable case, we can let the time path of external shocks$\{P_t\}$ and macroeconomic variables $\{E_t\}$ sequence and let the time path of macroeconomic variables $\{E_t\}$ sequence be affected by current and past realizations of the external shocks $\{P_t\}$. Consider the simple bivariate system

$$P_t = b_{10} - b_{12} E_t + \gamma_{11} P_{t-1} + \gamma_{12} E_{t-1} + \varepsilon_{Pt} \quad \text{... (3.1)}$$

$$E_t = b_{20} - b_{21} P_t + \gamma_{21} P_{t-1} + \gamma_{22} E_{t-1} + \varepsilon_{Et} \quad \text{… (3.2)}$$

Where, it is assumed that

(i) External shocks$\{P_t\}$ and macroeconomic variables $\{E_t\}$,

(ii) both $\{P_t\}$ and $\{E_t\}$ are stationary,

(iii) ε_{Pt} and ε_{Et} are white-noise disturbances with standard deviations of σ_P and σ_E respectively, and

(iv) $\{\varepsilon_{Pt}\}$ and $\{\varepsilon_{Et}\}$ are uncorrelated white-noise disturbances.

The structure of the system incorporates feedback, since $P_t$and$E_t$are allowed to affect each other. For example, $-b_{12}$ is the contemporaneous effect of a unit change of E_t on $P_t$andγ_{12} is the effect of a unit change in E_{t-1} on P_t. The terms ε_{Pt} and ε_{Et} are pure innovations (or shocks) in $P_t$andE_t respectively. If b_{21} is not equal to zero,ε_{Pt} has an indirect contemporaneous effect on $E_t$and if b_{12} is not equal to zero, ε_{Et} has an indirect contemporaneous effect on P_t.

The Equations *3.1* and *3.2* are not reduced form equations since E_t has a contemporaneous effect on $P_t$and$P_t$has a contemporaneous effect on E_t. Using the matrix algebra, the system of equations can be transformed into a more usable and compact form. Rewriting the system of equations in matrix form we get:

$$Bx_t = \Gamma_0 + \Gamma_1 x_{t-1} + \varepsilon_t \quad \text{... (3.3)}$$

Where,

$$B = \begin{bmatrix} 1 & -b_{12} \\ -b_{21} & 1 \end{bmatrix}; \quad x_t = \begin{bmatrix} P_t \\ E_t \end{bmatrix}; \quad \Gamma_0 = \begin{bmatrix} b_{10} \\ b_{20} \end{bmatrix}; \Gamma_1 = \begin{bmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{bmatrix} \text{ and}$$

$$\varepsilon_t = \begin{bmatrix} \varepsilon_{Pt} \\ \varepsilon_{Et} \end{bmatrix}$$

Equation *3.3* represents primitive form of VAR. Pre-multiplication by B^{-1} in Equation *3.3* gives us the Vector Autoregressive (VAR) model in standard form:

$$x_t = A_0 + A_1 x_{t-1} + e_t \quad \text{... (3.4)}$$

Where, $A_0 = B^{-1}\Gamma_0$; $A_1 = B^{-1}\Gamma_1$, and $e_t = B^{-1}\varepsilon_t$. The process in Equation *3.4* looks like an autoregressive process but with a difference that x_t, A_0 and e_t are now vectors. For notational purposes, we can define a_{i0} as element *i*of the vector A_0; a_{ij}as the element in row *i*and column *j* of the matrix A_1; and e_{it} as the element *i* of the vector e_t. Using this notation, the Equation *3.4* can be rewritten in the equivalent form:

$$P_t = a_{10} + a_{11}P_{t-1} + a_{12}E_{t-1} + e_{1t} \quad \text{... (3.5)}$$

$$E_t = a_{20} + a_{21}P_{t-1} + a_{22}E_{t-1} + e_{2t} \quad \text{... (3.6)}$$

It is important to note that the error terms (i.e. e_{1t} and e_{2t}) are composites of the two shocks ε_{Pt} and ε_{Et}.. Since $e_t = B^{-1}\varepsilon_t$, e_{1t} and e_{2t}can be computed as:

$$e_{1t} = (\varepsilon_{Pt} - b_{12}\varepsilon_{Et})/(1 - b_{12}b_{21}) \quad \text{... (3.7)}$$

$$e_{2t} = (\varepsilon_{Et} - b_{21}\varepsilon_{Pt})/(1 - b_{12}b_{21}) \quad \text{... (3.8)}$$

Since ε_{Pt} and ε_{Et} are white noise processes, it follows that both e_{1t} and e_{2t} have zero means, constant variances and are individually serially uncorrelated. But the critical point to be noted is that the covariance between $e_{1t}$and e_{2t}will not be zero so that two shocks will be correlated. In the special case, where $b_{12} = b_{21} = 0$ (i.e. if there are no contemporaneous effects of P_t on E_t and E_t on P_t), the shocks will be uncorrelated. It is useful to determine the variance and covariance matrix of the $e_{1t}$and e_{2t}shocks as:

$$\sum = \begin{bmatrix} \text{var}(e_{1t}) & \text{cov}(e_{1t}, e_{2t}) \\ \text{cov}(e_{1t}, e_{2t}) & \text{var}(e_{2t}) \end{bmatrix}$$

Since all elements of $\sum$ are times independent, we can use the more compact form:

$$\Sigma = \begin{bmatrix} \sigma_1^2 & \sigma_{12} \\ \sigma_{21} & \sigma_2^2 \end{bmatrix}$$

Where, $var(e_{it}) = \sigma_i^2$ *and* $\sigma_{12} = \sigma_{21} = cov(e_{1t}, e_{2t})$.

3.4.2. Exogeneity in VAR Model

A necessary condition for the exogeneity of St is that current and past values of E_t do not affect S_t. The sequence {St} may not exogenous to $\{E_t\}$ even though $\{E_t\}$ does not Granger cause {St}. Because pure shocks to $\{E_t\}$, i.e. ε_{Et}, may affect the value of {St}, though $\{E_t\}$ sequence does not Granger cause the {St} sequence.

A block exogeneity test is useful to determining whether to incorporate a variable into a VAR. Given the above distinction between causality and exogeneity, the multivariate generalization of the Granger-Causality test should be called a 'block causality' test. In any event, the issue is to determine whether the lags of one variable, say W_t Granger cause any of the variables in the system. In the three variables case, W_t, Stand E_t, the test is whether lags of W_t in the Stand E_t, equations to be equal to zero. This cross equation restriction is properly tested using the likely hood ratio test given as follows:

$(T-c)\ (\log|\Sigma_r| - \log|\Sigma_u|)$

Where, Σ_u and Σ_r are the variance and covariance matrixes of the unrestricted and restricted respectively.

3.4.3. Impulse Response Function (IRF)

The impulse response function (IRF) shows the dynamic responses of all variables in the system to a shock or innovation in each variable. For computing IRFs, it is essential that the variables in the system areordered and that the system is represented by a moving average process. The vector moving average (VMA) representation of Equation *3.7* expresses the variables P_t and E_t in terms of current and past values of the two shocks ε_{Pt} and ε_{Et}.

Writing Equations *3.5*and *3.6 in* matrix form, we get:

$$\begin{bmatrix} P_t \\ E_t \end{bmatrix} = \begin{bmatrix} a_{10} \\ a_{20} \end{bmatrix} + \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} + \begin{bmatrix} P_{t-1} \\ E_{t-1} \end{bmatrix} + \begin{bmatrix} e_{1t} \\ e_{2t} \end{bmatrix} \quad \text{... (3.9)}$$

Now, recalling the VAR model in standard form, i.e. Equation *3.7*, we have:

$x_t = A_0 + A_1 x_{t-1} + e_t$

If we iterate back-wards and assume that stability condition is met, then the particular solution for $x_t$is:

$$x_t = \mu + \sum_{i=o}^{\infty} \phi_1^i e_{t-i} \quad \text{.. (3.10)}$$

Where $\mu = [\bar{P}, \bar{E}]$

Using Equation *3.10*we can rewrite Equation *3.11* as:

$$\begin{bmatrix} P_t \\ E_t \end{bmatrix} = \begin{bmatrix} \bar{P} \\ \bar{E} \end{bmatrix} + \sum_{I=0}^{\infty} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}^i \begin{bmatrix} e_{1t-i} \\ e_{2t-i} \end{bmatrix} \quad \text{... (3.11)}$$

Equation *3.11* expresses $P_t$andE_t in terms of the $\{e_{1t}\}$ and $\{e_{2t}\}$ sequences. However, it is possible to rewrite Equation *3.11 in* terms of $\{\varepsilon_{Pt}\}$ and $\{\varepsilon_{Et}\}$ sequences. From equation *3.7*and *3.8*, the vector of error terms can be written as:

$$\begin{bmatrix} e_{1t} \\ e_{2t} \end{bmatrix} = (1/1 - b_{12}b_{21}) \begin{bmatrix} 1 & b_{12} \\ b_{21} & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_{Pt} \\ \varepsilon_{Et} \end{bmatrix} \quad \text{... (3.12)}$$

Now, Equations *3.11*and *3.12*can be combined to form:

$$\begin{bmatrix} P_t \\ E_t \end{bmatrix} = \begin{bmatrix} \bar{P} \\ \bar{E} \end{bmatrix} + (1/1 - b_{12}b_{21}) \sum_{i=0}^{\infty} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}^i \begin{bmatrix} 1 & b_{12} \\ b_{21} & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_{St} \\ \varepsilon_{Et} \end{bmatrix} \text{ .. (3.13)}$$

To simplify the above notation, now define the 2 x 2 matrix ϕ_i with elements ϕ_{jk} (i) such that:

$$\phi_i = [A_1^i /(1-b_{12}b_{21})]\begin{bmatrix} 1 & b_{12} \\ b_{21} & 1 \end{bmatrix}$$

Hence, the moving average representation of Equations *3.12*and *3.13* can be written in terms of $\{\varepsilon_{Pt}\}$ and $\{\varepsilon_{Et}\}$ sequences:

$$\begin{bmatrix} P_t \\ E_t \end{bmatrix} = \begin{bmatrix} \bar{P} \\ \bar{E} \end{bmatrix} + \sum_{i=o}^{\infty} \begin{bmatrix} \phi_{11}(i) & \phi_{12}(i) \\ \phi_{21}(i) & \phi_{22}(i) \end{bmatrix} \begin{bmatrix} \varepsilon_{St-i} \\ \varepsilon_{Et-i} \end{bmatrix}$$

Or, more compactly:

$$x_t = \mu + \sum_{i=0}^{\infty} \phi_i \varepsilon_{t-i} \qquad \text{... (3.14)}$$

The moving average representation is especially useful to examine the interaction between $\{P_t\}$ and $\{E_t\}$ sequences. The coefficients of ϕ_i can be used to generate the effects of ε_{Pt} and ε_{Et}shocks on the entire time paths of the $\{P_t\}$ and $\{E_t\}$ sequences. The four elements ϕ_{jk} *(0)* are called as impact multipliers. For example, coefficient ϕ_{12} *(0)* is the instantaneous impact of a one unit change in ε_{Et} on P_t. Similarly, the elements ϕ_{11} *(1)* and ϕ_{12} *(1)* are the one-period response of unit changes in ε_{Pt-1} and ε_{Et-1} on P_t respectively.

The four sets of coefficients $\phi_{11}(i),\phi_{12}(i)$, $\phi_{21}(i)$ and $\phi_{22}(i)$ are called impulse response functions. Plotting the impulse response functions [i.e. plotting the coefficients of $\phi_{jk}(i)$against *i*] is a practical way to visually represent the behaviour of the $\{P_t\}$ and $\{E_t\}$ series in response to the various shocks. With knowledge of knowing all the parameters of the primitive system of Equations *(3.1)* and *(3.2*), it is possible to trace out the time paths of the effects of pure ε_{Pt} or ε_{Et} shocks. However, this methodology is not applicable if the estimated VAR is under or over identified. Here, in this example, the estimated VAR is under-identified, because primitive VAR system contains 10

parameters whereas VAR in standard form contains only 9 parameters. So, an additional restriction on the VAR system must be imposed in order to identify the impulse responses. One possible identification restriction is to use the *Choleski decomposition*. For example, it is possible to contain the system such that the contemporaneous value of $P_t$does not have a contemporaneous effect on E_t. Finally, this restriction is represented by setting $b_{21} = 0$ in the primitive system. In terms of Equation *(3.12*), the error terms can be decomposed as follows:

$$e_{1t} = \varepsilon p_t + b_{12}\varepsilon_{ET} \quad \ldots\ldots\ldots \quad (3.15)$$

$$e_{2t} = \varepsilon_{Et} \quad \ldots\ldots\ldots \quad (3.16)$$

Equation *3.16* shows all the observed errors from the $\{e_{2t}\}$ sequence are attributed to ε_{Et} shocks. Given the calculated $\{\varepsilon_{Et}\}$ sequence, knowledge of the values of the $\{e_{1t}\}$ sequence and the correlation coefficient between $e_{1t}$and e_{2t} allows for the calculation of the $\{\varepsilon_{Pt}\}$ sequences using equation *3.15*. Although this decomposition contains the system such that a ε_{Pt} shock has no direct effect on E_t, there is an indirect effect in that lagged values of $P_t$that affect the contemporaneous value of E_t. The key point is that the decomposition forces potentially important asymmetry on the system, because ε_{Et} has contemporaneous effects on both P_t and E_t. For this reason, Equations *3.15* and *3.16* imply an ordering of variables. An ε_E shock directly affects $e_{1t}$and e_{2t}, but anε_{Pt} shock does not affect e_{2t}. Hence, $E_t$is 'prior' to P_t. Alternatively, by putting $b_{12} = 0$, the errors can be decomposed as:

$$e_{1t} = \varepsilon p_t$$

$$e_{2t} = b_{21}\varepsilon_{pt} + \varepsilon_{Et}$$

It is crucial to note that the importance of the ordering depends on the magnitude of the correlation coefficient between $e_{1t}$and e_{2t}. For example, if the correlation coefficient is equal to zero, the ordering is immaterial. Finally, Equations *3.15* and *3.16* can be replaced with $e_{1t} = \varepsilon_{Pt}ande_{2t} = \varepsilon_{Et}$. On the other hand, if the correlation coefficient

is unity (so that two shocks are equivalent), it is inappropriate to attribute the shock to a single source.

3.4.4. Variance Decomposition

Variance decomposition is used to detect the causal relation among the variables. It explains the extent to which a variable is explained by the shocks in all the variables in the system. The forecast error variance decomposition explains the proportion of the movement's private foreign capital inflows in a sequence due to its own shock versus shocks to the other macroeconomic variable. The VAR in standard form, i.e. Equation *3.4 is* written as follows:

$$x_t = A_0 + A_1 x_{t-1} + e_t$$

Now, suppose the coefficient $A_0$and A_1 is known and we want to forecast the various values of x_{t+1} conditional to the observed value of x_t. Updating the above equation by one period (i.e. $x_{t+1} = A_0 + A_1 x_t + e_{t+1}$), the conditional expectation of x_{t+1} is:

$$E_t x_{t+1} = A_0 + A_1 x_t$$

Here, one-step ahead forecast error is $x_{t+1} - E_t x_{t+1} = e_{t+1}$. Similarly, the two-step ahead forecast error of x_{t+2} is:

$$E_t x_{t+2} = [1 + A_1]\, A_0 + A_1^2 x_t$$

The two-step ahead forecast error is $e_{t+2} + A_1 e_{t+1}$. More generally the n-step ahead forecast is:

$$E_t x_{t+n} = [1 + A_1 + A_1^2 + \ldots\ldots + A_1^{n-1}]A_0 + A_1^n x_t$$

And, the associated forecast error is:

$$E_{t+n} + A_1 e_{t+n-1} + A_1^2\, e_{t+n-2} + \ldots\ldots\ldots + A_1^{n-1} e_{t+1}$$

It is possible to write the forecast errors in terms of the ε_{Pt} and ε_{Et} shocks. The forecast error variance decomposition tells the proportion of their movements in a sequence due to its own shock versus shocks to the other variable. If ε_{yt}shocks explain

none of the forecast error variances of ε_{Pt} at all forecast horizons, it can be said that $\{P_t\}$ sequence is exogenous. In such a circumstance, the $\{P_t\}$ sequence would evolve independently of the ε_{Et} shocks and of $\{E_t\}$ sequence. On the other hand, if ε_{Et} shocks explain all of the forecast error variances in $\{P_t\}$ sequence at all forecast horizons, then $\{P_t\}$ would be entirely endogenous.

3.5. Result and Discussion

The motive of this chapter is to find out the domestic and imported factor, that affects the level of inflation of Indian economy. When we are looking for core inflation, we exclude the volatile commodities from the price index to get the underlying level of inflation. But only a nature of the commodities doesn't affect the level of inflation; there are also many other factors that affect the level of inflation like external sector. Those commodities which highly associated with international trade contribute more to imported level of inflation. So, we aim to identify the tradable and non-tradable inflation, and considering non-tradable inflation representing core or purely domestic inflation. But our study is limited to the traditional definition of tradable and non-tradable inflation i.e. goods are tradable and services are non-tradable commodities in consumption basket.

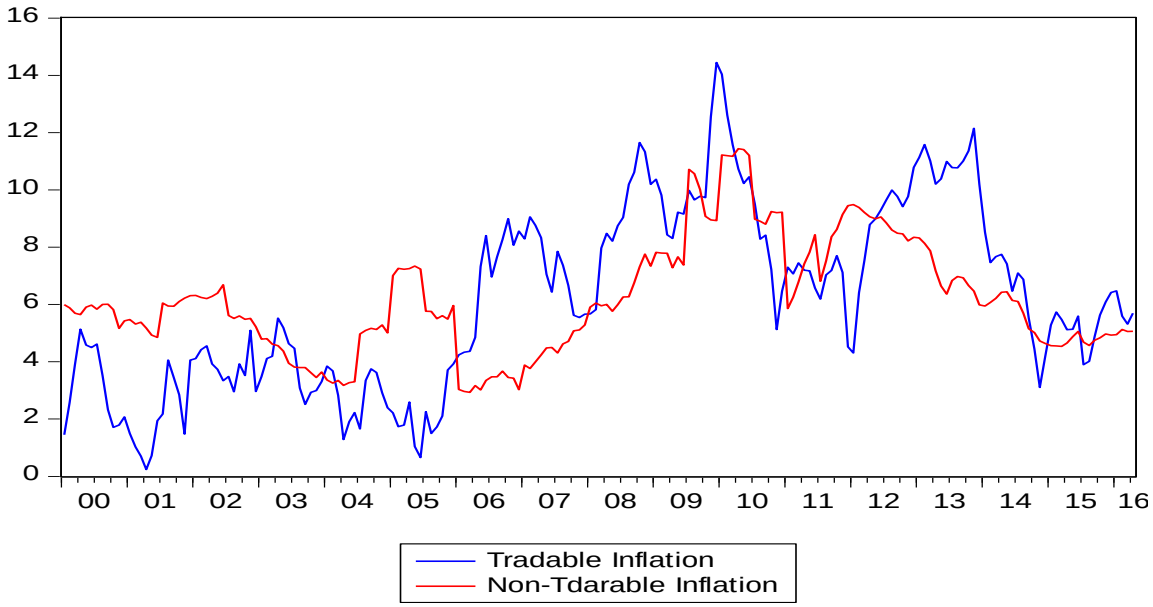


Figure 3.1: Tradable and Non-Tradable Inflation for India

Source: Author's Calculation

The above figure 3.1 presents the tradable and non-tradable inflation for India form the period of January 2000 to March 2016. We find that, tradable inflation is highly volatile in nature in comparison to non-tradable inflation; as tradable inflation highly is responsive to the changes in external sector. The changes in external sector affect the level of inflation mainly through the channel of exchange rate and oil price. Hence, we tested how exactly tradable and non-tradable inflation response to changes in exchange rate and oil price. For that we have empirically estimated the relationship between (REER) Real Effective Exchange Rate, crude oil price, tradable and non-tradable inflation by using VAR model.

Table 3.1
Unit Root Test Results (ADF Test without Trend)

Variables	t-statistics	P Value
At Level		
Tradable Inflation	-2.46	0.12
Non-Tradable Inflation	-2.08	0.25
REER	-3.80	0.07
Oil	-2.06	0.06
First Difference		
Tradable Inflation	-11.95	0.00*
Non-Tradable Inflation	-14.21	0.00*
REER	-10.64	0.00*
Oil	-10.87	0.00*

*Note: * indicates the tabulated value at 5% level of significance i.e. -3.42.*
Source: Author's Calculation

The above table 3.1 presents the unit root test without trend result. All the variables are non-stationary at the level i.e. we cannot reject the null hypothesis of presence of unit root. Then we converted all the variables to first difference and found all the variables are stationary at first difference and integrated of order one, i.e., I (1) process and now we can reject the null hypothesis of presence of unit root. Then we proceed for Johansen Juselius co-integration test to find out whether any long run relationships exist among the variables or not.

Table 3.2
Result of Johansen Co-integration Test

Hypothesized No. of CE(s)	Eigen value	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.124521	24.33599	27.58434	0.1234
At most 1	0.080717	15.40159	21.13162	0.2617
At most 2	0.034598	6.443582	14.26460	0.5570

*Note: * indicates the tabulated value at 5% level of significance i.e. -3.42.*
Source: Author's Calculation

The above table 3.2 presents the result of Johansen Juselius co-integration test. The test does not find any co-integrating or long run relationship among variables. Then we proceed for VAR analysis and find the impulse response function to find how one standard deviation shock to one variable is affecting to the other variables.

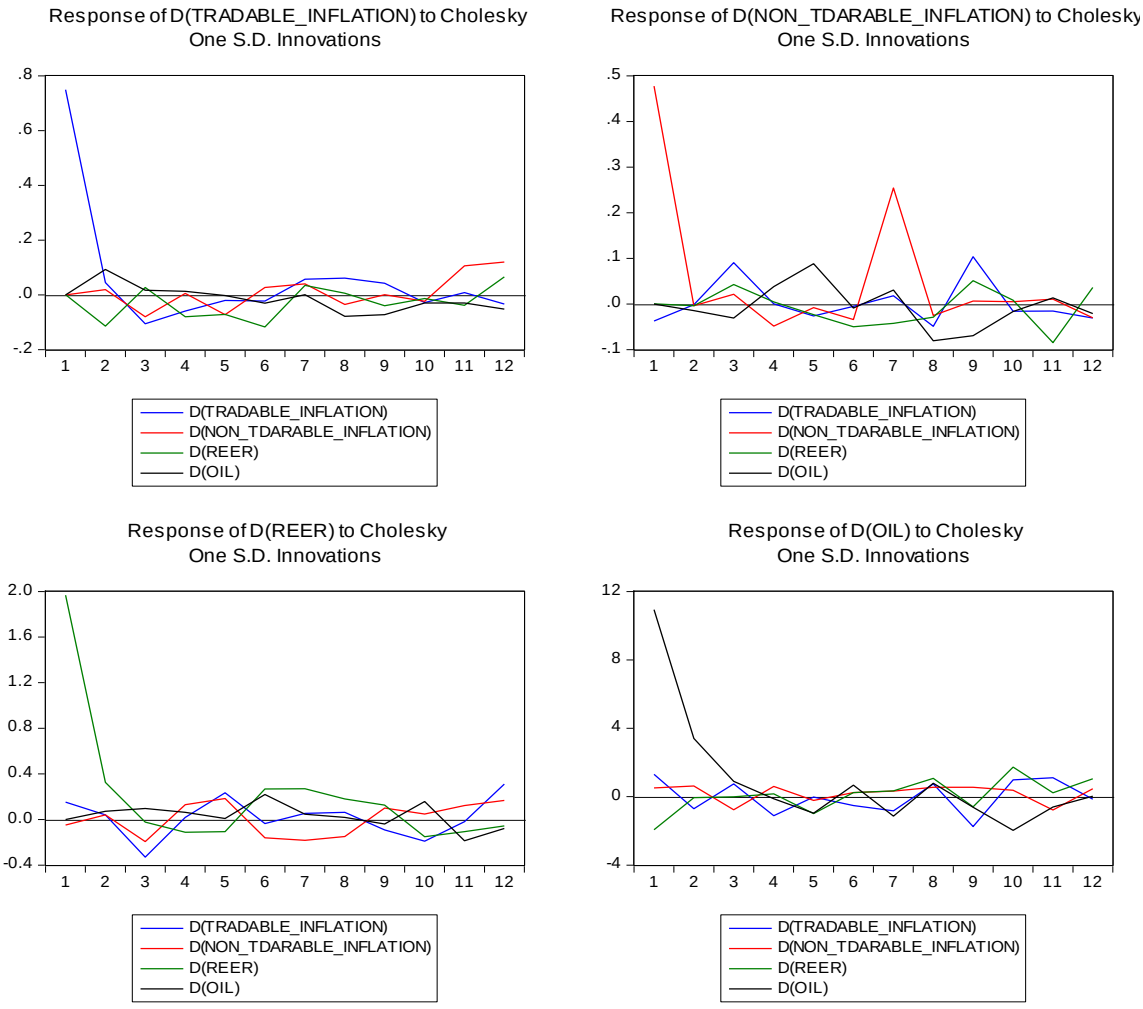


Figure 3.2: Impulse Response Function
Source: Author's Calculation

The above figure 3.2 presents the impulse response of one standard deviation shock to the other variables. In response to one standard deviation shock to exchange rate (REER), tradable inflation become highly volatile in nature and becoming stable after ninth period. Non-tradable inflation also gets fluctuated in response to the shock of REER but it is less volatile in comparison to tradable inflation, but after eighth period it is becoming high volatile i.e. it is volatile after some period external factors shock transfer from tradable to non-tradable goods. While in case of one standard deviation shock to oil price leads to an immediate rise in tradable inflation and start to fall in the second period, and again start to respond in the seventh period. But, in case of non-tradable inflation, it starts to respond after the second period but after that gets highly fluctuated and become stable after the tenth period. From the above analysis, we can see that, both tradable and non-tradable inflation affected by external shocks i.e. shocks to the exchange rate and oil price. But the shocks from external sectors have an immediate effect on tradable inflation, and non-tradable inflation takes some time lag to respond to the external shocks.

Table 3.3
Variance Decomposition Result

Variance Decomposition of D(Tradable Inflation)					
Period	**S.E.**	**D(Tradable Inflation)**	**D(Non Tradable Inflation)**	**D(REER)**	**D(Oil)**
1	0.749097	100	0	0	0
2	0.764936	96.23668	0.063498	2.244553	1.455265
3	0.777031	95.11823	1.133881	2.291221	1.456672
4	0.783517	94.12526	1.119545	3.295816	1.459376
5	0.790407	92.56019	1.934276	4.070427	1.435108
6	0.800417	90.34169	1.994855	6.119136	1.544321
7	0.804166	90.00019	2.222582	6.247234	1.529995
8	0.811128	89.02561	2.376222	6.145353	2.452819
9	0.816426	88.14292	2.345527	6.301378	3.210178
10	0.817905	87.94562	2.418578	6.306644	3.329161
11	0.826258	86.18651	4.021295	6.39746	3.394737
12	0.839772	83.59877	5.929299	6.797149	3.674783
Variance Decomposition of D(Non Tradable Inflation)					
Period	**S.E.**	**D(Tradable Inflation)**	**D(Non Tradable Inflation)**	**D(REER)**	**D(Oil)**
1	0.478861	0.603877	99.39612	0	0
2	0.479114	0.60457	99.29829	0.00649	0.090646

3	0.490903	3.979161	94.77543	0.765756	0.479656
4	0.494775	3.917188	94.26406	0.762317	1.056437
5	0.503875	4.05061	90.91606	0.952858	4.080474
6	0.507614	4.001659	90.03178	1.912818	4.053741
7	0.570452	3.266491	91.16061	2.077055	3.495847
8	0.579499	3.882115	88.53079	2.261364	5.325728
9	0.594995	6.71528	83.98973	2.87443	6.420564
10	0.595509	6.776046	83.8513	2.887543	6.485112
11	0.601994	6.697906	82.08459	4.82251	6.394992
12	0.605019	6.891792	81.52051	5.132464	6.455229
Variance Decomposition of D(REER)					
Period	**S.E.**	**D(Tradable Inflation)**	**D(Non Tradable Inflation)**	**D(REER)**	**D(Oil)**
1	1.973024	0.587204	0.060911	99.35188	0
2	2.001758	0.610282	0.099679	99.16306	0.126976
3	2.040421	3.206096	0.997423	95.4524	0.344083
4	2.048755	3.187942	1.394847	94.97951	0.437698
5	2.072998	4.379019	2.154621	93.03709	0.42927
6	2.108169	4.263241	2.670345	91.56361	1.502802
7	2.134308	4.223346	3.34415	90.9183	1.514199
8	2.147976	4.253361	3.783902	90.46077	1.501964
9	2.156256	4.402102	3.970325	90.10434	1.52323
10	2.176243	5.094848	3.945716	88.93959	2.019841
11	2.190355	5.037544	4.202346	88.03696	2.723145
12	2.220651	6.851277	4.656721	85.71637	2.775634
Variance Decomposition of D(Oil)					
Period	**S.E.**	**D(Tradable Inflation)**	**D(Non Tradable Inflation)**	**D(REER)**	**D(Oil)**
1	11.20058	1.363329	0.207797	2.979781	95.44909
2	11.74447	1.603822	0.46754	2.712426	95.21621
3	11.8265	1.977682	0.875673	2.674945	94.4717
4	11.89541	2.827187	1.118083	2.663566	93.39116
5	11.97766	2.788969	1.135602	3.306891	92.76854
6	12.01204	2.956869	1.167341	3.327091	92.5487
7	12.10339	3.386098	1.22396	3.352563	92.03738
8	12.2111	3.697853	1.403102	4.064765	90.83428
9	12.37783	5.600326	1.565993	4.182047	88.65163
10	12.69504	5.922389	1.573362	5.823787	86.68046
11	12.78394	6.5982	1.928255	5.773718	85.69983
12	12.83564	6.558302	2.044332	6.386117	85.01125
Cholesky Ordering: D(Tradable Inflation) D(Non Tradable Inflation) D(REER) D(Oil)					

Source: Author's Calculation

The above table 3.3 presents the result of variance decomposition of REER, oil, tradable and non-tradable inflation. From the result variance decomposition also we can see that, with the passage of time the effect of external shocks transmits from tradable to non-tradable inflation with second round effect. Initially, variation in non-tradable inflation is explain by its own shock but by the end of twelfth month percentage of variation explained by its own shock decrease and by other variables such as tradable inflation, REER and oil increases. In the first month around 99 percent of variation explained by its own shock only 0.6 percent variation explained by tradable inflation. By the end of twelfth month 81 percent variation explained by its own shock, 6.89, 6.45 and 5.13 percent variation explained by tradable inflation, REER and oil respectively.

3.6. Conclusion

This chapter aims to find, how external shocks affects the tradable and non-tradable inflation of India. To represent the external shocks, we have taken REER and oil price, as these two parameters are main channel of pass through of external shocks. Rise in oil price leads to an inflationary shock in the economy through two different channels. In the first round, it directly affects the price of energy products and indirectly affects the energy related cost of production of other goods and services. In the second round, increase in cost of living leads to a demand for increase in wage among workers to maintain their real income. The study also finds the same result. External shocks have an immediate effect on tradable inflation as they are directly associated with external economy; while it takes time to affect the non-tradable inflation. It affects the non-tradable sectors in the second round effect of the external shocks. Core inflation is estimated by excluding volatile goods from the consumption basket; but this volatility of the commodities may be not due to its nature of the commodity, and may be because of external shocks. Excluding these commodities does not fully extract the temporary fluctuations; there may be an existence of second round effect of external shocks in the core inflation.

Chapter 4

Role of Asset Price in Inflation in India

4.1. Introduction

Central banks of many countries have single objective of maintaining price stability, after they announces themselves as inflation targeting countries. To achieve the objective, they are using "Core inflation" as inflation targeting measure. Even many countries looking both headline and core inflation as inflation targeting measure. While looking for core inflation as inflation targeting measure, they are looking for some basic properties like easy calculation of the core measure, transparency to public, timeliness, less volatile in nature and the last and important one is forecasting ability. Forecasting ability or analysing expected inflation is very important aspect of maintaining price stability as people behave according to rational expectation. According to Alchain and Klein (1972) instead of looking to only current consumption basket for measuring inflation, we must focus on the current cost of expected life time consumption; because, people lives in two periods. Not only they have consumed in current period but they also save for future and invest in future. Therefore, we also need toconsider the future expectations of individuals,while considering individuals' investment in future or their behaviour towards future expectations of prices, and we must consider the asset prices as indicator of these things. Because, asset prices can better represent the future movement of prices. In addition, we can identify aspiring credit bubbles and take necessary monetary policy actions. According to John and Das (2011), asset price as the indicator of future expectations can help in assessing the timing and usefulness of policy actions and can help in maintaining financial stability in the economy. The UK central bank already started working on that. To avoid housing price bubbles, the office for National Statistics has introduced a measure of CPI (Consumer Price Index) that includes housing price, known as CPIHwhich was first published on 19th march 2013. According to Roy and Chatterjee (2001), a conventional starting point for assessing the information content

of financial asset prices as embodied in nominal interest rates in the fisher equation: $i = r + \pi^e$; where i,r and π^e denote the nominal interest rate, the real interest rate and the expected inflation rate respectively. In the absence of risk premia and money illusion and assuming r to be constant, the equation portrays a one-to-one relationship between nominal interest rate and expected inflation. In other words, since the returns from the financial asset would be obtained over a period in the future, according to the fisher equation, the investors would like to be fully compensated. Because, the likely/expected inflation rate that would prevail during that period leadingto earn specified constant real rates of return. Given a real rate of return, nominal interest rates or the current price of a financial asset, therefore, reflect the inflation rate expected to prevail in the future. Assuming that, a relationship can be drawn between the expected future inflation rate and the actual future inflation rate, the current financial asset price conceptually contains information about the future inflation rate.

The problem of asset prices is that, it is highly fluctuating in nature and they are more volatile than the items in normal consumption baskets of individuals. However, we cannot react to all the movements of asset prices. If any movements in asset prices signalling any inflationary or deflationary situation, then only monetary policy must react to asset price movements. That means we have to find out the misalignments of asset prices even if it is very difficult task. According to Hordohl and Packer (2007), monetary policy makers face at least two general sets of questions while working with asset price fluctuation: (a) "what are the information it content?" and (b) "given the information it content, how should policymakers respond to movements in these markets?"Hence, our first focus must be on identifying asset price bubbles. Siegel (2003) gives an operational definition of asset price bubble as "a period of rising (or falling) prices in an asset market can be described as a bubble (or a negative bubble) at time t if it can be shown that the realized return of the asset over a given future time period, that time period defined by the duration of the asset, can be shown to be inconsistent, i.e. more than two standard deviation from the expected return, given the historical risk and return characteristics of that asset at time t." While Capozza et al (2002) proposed a

methodology to determine the long-term and short-term determinants of asset price movements. The methodology is divided into three steps:

(a) The fundamental value of asset is calculated by using economic conditions and institutional arrangements.

(b) The short-term dynamics of prices are determined by a mean reversion process to their fundamental values and by a serial correlation movement.

(c) Finally, interactive terms are introduced to investigate the impact of institutional factors on asset price dynamics.

According to Gali (2014), the optimal policy must strike a balance between stabilization of current aggregate demand, which call for appositive interest rate response to the bubble and stabilization of the bubble itself, which would warrant a negative interest rate response to the bubble. He also mentioned that monetary policy cannot affect the conditions for existence or non-existence of a bubble, but it can influence its short run behaviour, including the size of its fluctuation.

Still after a decade of inflation targeting, considering core inflation to maintain price stability is questionable. While, we are looking for inflation targeting or core inflation, we calculate inflation after excluding most volatile commodities. Generally, we try to find out underlying trend of the inflation by excluding temporary fluctuations. While looking for forecasting ability of the core inflation, we are trying to get it from asset price by including it to our normal consumption basket, which is most volatile item. But, here the question arises, on the one side, we are excluding some temporary fluctuations for getting underlying trend, and on the other side we are including most volatile item to get better forecasting result of inflation. Therefore, our main question is, whether considering asset prices for calculating inflation is good idea or not. Second question is how it is working at the time when Indian economy recently faced a lot of problem at a time like, currency devaluation, current account deficit, rise of oil and food prices, rise of gold import etc. These situations ultimately lead to an inflationary situation in the economy. In this situation, considering asset price is helpful to maintain price stability in the economy or not. Roy and Chatterjee (2001) found that, the impact of

stock prices on commodity price inflation in India from the period of 1994 to 2000. As a result, they find that, stock price inflation does not affect output gap but it granger cause commodity price inflation. They also give special attention to gold price and exchange rate and they find that these variables do not emerge as a leading indicator of commodity price inflation. While Purfield (2007) examine the effect of asset price on the different macroeconomic variable of India. The author observed that the rapid structural changes of Indian economy making it difficult to identify price misalignments. And as the relationship between monetary policy and asset price is low, the macro economic impact of asset price correction is likely to be small.

Now a day, policy rate mainly affects the future and not the present inflation, as it operates with lag. So, the policy must be a forward looking and should be based on their expectation of inflation in the future. According to Alan Greenspan that potential asset price bubbles were not something to worry about. Such "rational bubbles" should be allowed to grow and burst on their own, and monetary policy should stay focused only on inflation. But, then the problem is, policy makers must realise how painful a recession and how slow a recovery would follow an asset price bubble, especially one followed by credit growth.

4.2. Review of Literature

Batavia and Parameswar (2005) analysed whether asset price volatility consists any predictive link for consumer price inflation. The study uses two asset price i.e. houses and equities to test the predictive link between asset price and consumer inflationempirically. And the study gets a positive result that asset price helps in predicting consumer price inflation looking forward into one to two-year time horizon.The results indicate that, lagged asset price changes can be used along with labour market costs, money supply changes and credit market imperfections to predict consumer price inflation some quarters ahead.Similarly, Stock and Watson (2001) also empirically tested the role of asset price in forecasting output and inflation. The study uses quarterly data up to 38 candidate indicators (mainly asset prices) for seven OECD

countries from the period of 1959 to 1999. The result suggests that asset price has small marginal predictive content for output at the two, four and eight quarter horizon. It is better to combine information from large number of asset price can help in reliable forecast rather than following a single asset price.

Soni and Parashar (2015) examined the impact of gold price on overall consumer price inflation. Recently, India is becoming largest consumer of gold. What has its impact on inflation level?It is believed that gold consistsignificant information about future inflation level, especially for those have adopted inflation targeting regime. Andersson (2011) also examined the relation between asset price inflation, consumer price inflation and monetary policy. He found that, consumer price index does not include all the goods and services in an economy and it does not represent true monetary inflation. So, money growth can use as proxy for overall inflation rate. As a result,he found that money growth is correlated with asset price inflation in all short, medium and long period.

Bryan, Cecchetti and O'Sullivan (2000) found that the role of asset prices in the measurement of inflation. The study uses three asset prices i.e. equities, bonds and houses in the construction inflation index by assigning weight to these three items. As a result, the study finds that housing price plays a major role in measuring inflation trend in US and other countries also. As we know asset price itself is highly volatile in nature, then question is how monetary policies respond to these new indices after including asset prices. This study suggests that history changes each time new data areadded. Hence, only real time information should be used.

Bernanke and Gertler (2001) addressed the questions whether central bank should respond to movements in asset prices while conducting monetary policy. The study finds that too-aggressive response to stock prices can significantly harm to the economy. The study by Bollard (2004) also addressed the similar questions how monetary policy responds to asset price movements. The study concluded, that while monetary policy targeting inflation to keep it low, it automatically takes asset prices into account in terms

of their effect on general price inflation.Stulz (1986) finds a negative relation between asset pricing and expected inflation. Singh and Pattanaik (2010) also focused on the same question whether monetary policy should respond to movements of asset price in specific case of India. After sub-prime crisis of 2008 every nation starts concerning about whether monetary policy should become more sensitive to asset price movements. As a result, the study finds that, in case of India, monetary policy does not response to asset prices but the asset price channel of monetary policy transmission exists.

Al-Abri (2007)empirically tested the interaction between credits, financial asset price and consumer price inflation in case of Gulf Cooperation Council (GCC)countries using quarterly data from the period of 1998:1 to 2009:4. Stock price has a positive significant effect on CPI inflation only in Qatar and Oman, while domestic credit comes out as an important determinant of inflation in all the countries. Oil price increases affect inflation positively in Oman and Kuwait and negatively in Saudi Arabia; the effect may capture cross-subsidization of essential commodities by the government. The study also finds that the depreciated home currency in Saudi Arabia and Kuwait, although takes four quarters, strongly influence consumer price inflation. The findings of this study have important policy implications: (a) as GCC countries weigh the costs and benefits of moving away from their unilateral exchange rate peg to more flexible regimes; (b) for the challenges of a common monetary policy for the GCC area mandated by the proposed common currency.

Selody (2004) examined the relationship between asset price movements and monetary policy in specific case of Canadian economy. Housing-price bubbles should be a greater concern for Canadian monetary policy than equity-price bubbles, since rising housing prices are more likely to reflect excessively easy domestic credit conditions than are equity prices, which are largely determined in global markets.

4.3. Data and Methodology

To examine the role of asset price in inflation in India, we have considered asset price as a commodity of CPI index. We have taken three variables such as; gold, real estate and equity to represent asset price fluctuations in the economy. According to Purfield (2007) real estate is an important asset in India. Households saving comprise about 28% of disposable income in India. In 2004-05, about 53% of the annual flow of saving was invested in physical assets. India is the fourth largest commercial real estate market in Asia. In recent discourse of inflation, we have also witnessed how gold price is contributing to the inflation in India. The trend of both gold and equity price from April 2016 to June 2015 is given in the figure 4.1.

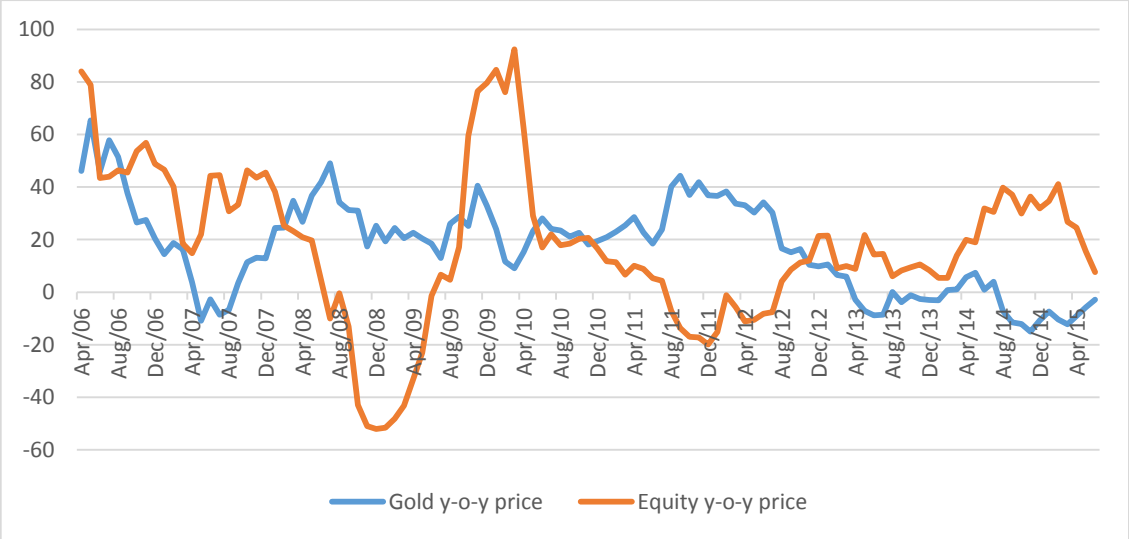


Figure 4.1: Gold and Equity Price in India
Source: Author's Calculation

We include these variables in the WPI index by assigning different weights to it. For this, we have adopted Neo-Edgeworthian Index. As we know inflation is chronic problem for Indian and whenever there is a high inflation in the economy, there are more investor specifically in gold. Gold import become a serious problem for Indianeconomy and to handle this situation we have reduce the level of inflation in the economy. The above figure 4.1 represents the gold equity price in the economy.

4.3.1. Neo-Edgeworthian Index

The Neo-Edgeworthian index is developed by Diewert (1995). This method is also known as variance weighted price index. But,Lafleche (1997) modified it by using standard deviation instead of variance.

$$W_i = \frac{\frac{1}{\delta_i^2}}{\sum_{i=1}^{N} \frac{1}{\delta_i^2}} \tag{4.1}$$

We have calculated inflation rate by alternatively adding the variables to the index. First, we calculated headline inflation without including any asset variable, and then we added the entire three variables individually and finally we added three variables together. After that, we smoothed all the series for getting core inflation andcross-checked the prediction ability of all the series.

4.3.2. Kalman Filter

For smoothing the series and forecasting we use Kalman filter method. Kalman filter method can be used to extract the common trend among all price series out of the price shocks of each good by assigning a weight to each good to minimize the sum of weighted idiosyncratic shocks in each period. The weight assigned to each price will vary over time depending on two factors, one is magnitudes of its correlation to others and variance of its idiosyncratic shock in each period. For applying Kalman filter process we have to specify our model in our state space form. Once a model has been put in state space form, the Kalman filter may be applied and this in turn leads to algorithms for prediction and smoothing. The Kalman filter also opens the way to maximum likelihood estimation of the unknown parameters in the model.

We can convert any other model to state space form. In our study, we are converting an Auto Regressive Moving Average (ARMA) model to a state space model. A state space model consists of two types of equations. First is measurement equation, which describes the relation between observed and unobserved variables. Second, transition equation, which describes the dynamics of unobserved variables.

General form of state space model is as follows:

Measurement Equation: $y_t = H_t\beta_t + Az_t + e_t$ (4.2)

Transition Equation: $\beta_t = \mu + F\beta_{t-1} + v_t$ (4.3)

$e_t \sim i.i.d.N(0, R)$ (4.4)

$v_t \sim i.i.d.N(0, Q)$ (4.5)

$E(e_t v_s') = 0$ (4.6)

Where, $y_t$an $n \times 1$ vector of variables is observed at time t; β_t is a $k\times1$ vector of unobserved state variables; H_t is an $n\times k$matrix that links the observed y_t vector and the unobserved β_t; z_t is an $r\times1$ vector of exogenous or predetermined observed variables; μ is $k\times1$; v_t is $k\times1$. Elements of the H_t matrix may either be data on exogenous variables or constant parameters.

As we have already mentioned an ARMA can also be convertedinto a state space form.

ARMA Specification: $y_t = \emptyset_1 y_{t-1} + \emptyset_2 y_{t-2} + w_t + \theta w_{t-1}$ (4.7)

State Space Specification are:

Measurement Equation: $y_t = [1 \quad \theta]\begin{bmatrix}\beta_{1,t}\\ \beta_{2,t}\end{bmatrix}$ (4.8)

Transition Equation: $\begin{bmatrix}\beta_{1,t}\\ \beta_{2,t}\end{bmatrix} = \begin{bmatrix}\emptyset_1 & \emptyset_2\\ 1 & 0\end{bmatrix}\begin{bmatrix}\beta_{1,t-1}\\ \beta_{2,t-1}\end{bmatrix} + \begin{bmatrix}w_t\\ 0\end{bmatrix}$ (4.9)

Once the model is expressed in state space form, then we can go for smoothing and prediction of the series.

Prediction: $\beta_{t\backslash t-1} = \mu + F\beta_{t-1\backslash t-1}$ (4.10)

$P_{t\backslash t-1} = FP_{t-1\backslash t-1F'} + Q$ (4.11)

$n_{t\backslash t-1} = y_t - y_{t\backslash t-1} = y_t - H_t\beta_{t\backslash t-1} - Az_t$ (4.12)

$f_{t\backslash t-1} = H_t P_{t\backslash t-1} H_t' + R$ (4.13)

Updating: $\beta_{t\backslash t} = \beta_{t\backslash t-1} + K_t n_{t\backslash t-1}$ (4.14)

$P_{t\backslash t} = P_{t\backslash t-1} - K_t H_t P_{t\backslash t-1}$ (4.15)

Where $K_t = P_{t\backslash t-1}H_t' f_{t\backslash t-1}^{-1}$ is the Kalman Gain.

Smoothing:

(t=T-1, T-2… 1) $$\beta_{t\backslash T} = \beta_{t/t} + P_{\frac{t}{t}}F' P_{t+1\backslash t}^{-1}(\beta_{t+1\backslash T} - F\beta_{t\backslash t} - \mu) \quad (4.16)$$

$$P_{t\backslash T} = P_{t\backslash t} + P_{t\backslash t}F' P_{t+1\backslash t}^{-1}(P_{t+1\backslash T} - P_{t+1\backslash t})P_{t+1\backslash t}^{-1\,\prime} F P_{t\backslash t}' \quad (4.17)$$

Where,$\beta_{t\backslash T}$ and$P_{t\backslash T}$, the initial values for smoothing, are obtained from the last iteration of the basic filter. The above discussions assume that the parameters of the model are known. However, some of these parameters are usually unknown. In this case, we need to estimate the parameters first, then the estimate of β_t , t=1, 2,…, T, will be conditional on theses parameters. For given parameters of the model, the kalman filter provides us with prediction error $(n_{t\backslash t-1})$ and its variance $(f_{t\backslash t-1})$ in equation (4.12) and (4.13). In addition, if β_0 and $\{e_t, v_t\}_{t=1}^{T}$ are Gaussian, the distribution of y_t conditional on ψ_{t-1} is also Gaussian:

$$y_t \backslash \psi_{t-1} \sim N(y_{t\backslash t-1}, f_{t\backslash t-1}) \quad (4.18)$$

And, the sample log likelihood function is represented by:

$$lnL = -\frac{1}{2}\sum_{t=1}^{T} \ln\left(2\pi \backslash f_{t\backslash t-1}\right) - \frac{1}{2}\sum_{t=1}^{T} n_{t\backslash t-1}' f_{t\backslash t-1}^{-1} n_{t\backslash t-1} \quad (4.19)$$

Which can be maximized with respect to unknown parameters of the model.

4.4.Empirical Results and Discussion

The study aims to estimate different level of inflation by including gold and equity as a commodity of consumption basket. For this, first we assign weight to the gold and equity by reweighting all the commodities in the price index according to its standard deviation by using Neo-Edgeworthian Index. Further,we proceed for forecasting of different inflation series by using Kalman filter. Before that, we need to check how CPI inflation is responding if one standard deviation shock is given to the gold and equity price. First we check whether the variables are stationary or not.

Table 4.1
Unit Root Test Result (ADF Test without Trend)

Variables	t-statistics	P Value
At Level		
CPI	-2.09	0.24
Gold	-3.32	0.15
Equity	-2.83	0.06
First Difference		
CPI	-11.91	0.00
Gold	-11.18	0.00
Equity	-13.64	0.00

*Note: * indicates the tabulated value at 5% level of significance i.e. -3.42.*
Source: Author's Calculation

The above table 4.1 presents the result of unit root test. All the variables are non-stationary at the level i.e. we cannot reject the null hypothesis of presence of unit root. Then, we converted all the variables to first difference and found all the variables are stationary at first difference and integrated of order one, i.e., I (1) process and now we can reject the null hypothesis of presence of unit root. That means, all variable follows the process of I(1). Then we proceed for JohansonJuseliusco-integration test.

Table 4.2
Result of Johansen Co-Integration Test

Hypothesized No. of CE(s)	Eigen value	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.095333	19.13595	21.13162	0.0930
At most 1	0.077741	15.45756	14.26460	0.0322
At most 2	0.019156	3.694386	3.841466	0.0546

*Note: *indicates the tabulated value at 5% level of significance i.e. -3.42.*
Source: Author's Calculation

The above table 4.2 presents the result of Johansen Juselius co-integration test and we do not find any co-integrating vector among the variables.That means there is no long run relationship among the variables. Further, we have estimated impulse response function to find out how one standard deviation shock to the gold and equity price is affecting the CPI inflation by using VAR model.

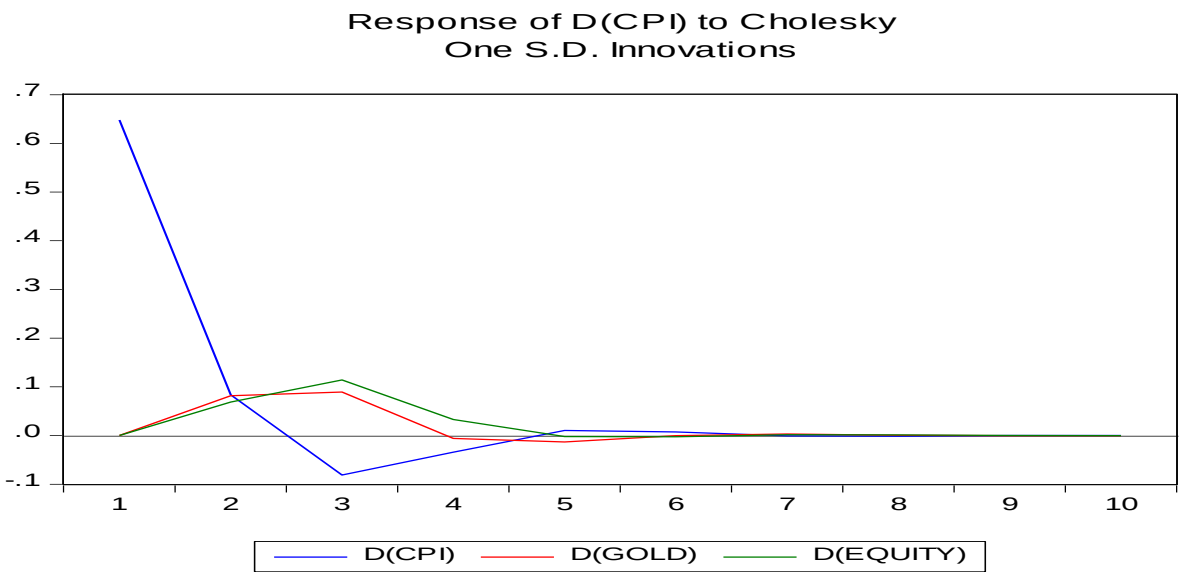


Figure 4.2: Impulse Response Function
Source: Author's Calculation

The above figure 4.2 presents the impulse response function of CPI inflation to one standard deviation shock to the gold and equity price. Any shock to gold or equity price is highly affecting the CPI inflation. The CPI inflation immediately get a hike in response to the shock in both gold and equity price. But, this hike is for little long period in response to shock of equity price than shock to gold price. In response to the shock of gold price the hiked inflation level it maintains that hike level from second period to third period, after third period, it starts to decline and the effect dies out after fourth and fifth period in response to shock of gold and equity price respectively.

After finding changes in gold and equity price have immediate effect on CPI inflation, we included gold and equity as commodity in consumption basket and assign different weights according to their standard deviation.

Table 4.3
Weighted Indices after including Gold and Equity

Commodities	CPI Weight	Reweighted including Gold	Reweighted including Equity	Reweighted including Gold & Equity
Cereals & Products	20.47	6.4187	6.4688	6.3746
Pulses & Products	3.59	2.0801	2.0963	2.0658
Oils & Fats	5.03	2.0137	2.0294	1.9998
Meat, Fish & Eggs	4.29	10.0570	10.1355	9.9879

Milk & Products	6.45	9.4251	9.4987	9.3603
Condiments & Spices	3.18	5.712	2.1265	2.0955
Vegetables & Fruits	5.71	1.9757	1.9911	1.9621
Other Food	8.28	6.0159	6.0628	5.9745
Pan, Supari, Tobacco & Intoxicants	3.51	7.6518	7.7115	7.5992
Fuel & Light	6.28	3.9849	4.0160	3.9575
Housing	8.67	4.6929	4.7295	4.6606
Clothing, Bedding & Footwear	8.54	7.3830	7.4407	7.3323
Medical Care	2.59	8.5518	8.6186	8.4930
Edu. Rec. & Amusement	3.14	6.6354	6.6872	6.5898
Transport & Communication	2.65	4.7212	4.7581	4.6888
Personal Care & Effects	3.31	7.3220	7.3792	7.2717
Others	4.67	7.4930	7.5515	7.4415
Gold	-	1.4668	-	1.4567
Equity	-	-	0.6977	0.6875

Source: Author's Calculation

The above table 4.3 presents the different weights assign to the different commodities after including gold and equity to the consumption basket by using neo-edgeworthian index. When we include only gold in to the CPI index then we assign 1.46 weight to it and 0.69 weight to the equity when we include only equity to the consumption index. Respectively the weight of other commodities also changes according to their standard deviation. The weight of cereals and products changes from 20.47 to 6.41 as it is one of the most volatile commodity in the consumption basket. The weight of other food products which decreases are pulses and products, oils and fats, vegetable and fruits and other food products. Other than food items weight of fuel and light, housing and clothing, bedding and footwear decreases. While the weight of meat, fish and eggs, milk and products, condiments and spices and other foods increases. The weight of pan, supari, tobacco and intoxicants, medical care, Edu. Rec. and amusement, transport and communication, personal care and effects and other increases.

After assigning different weights to the different commodities according to their respective standard deviation and including gold and equity we estimated weighted CPI indices.

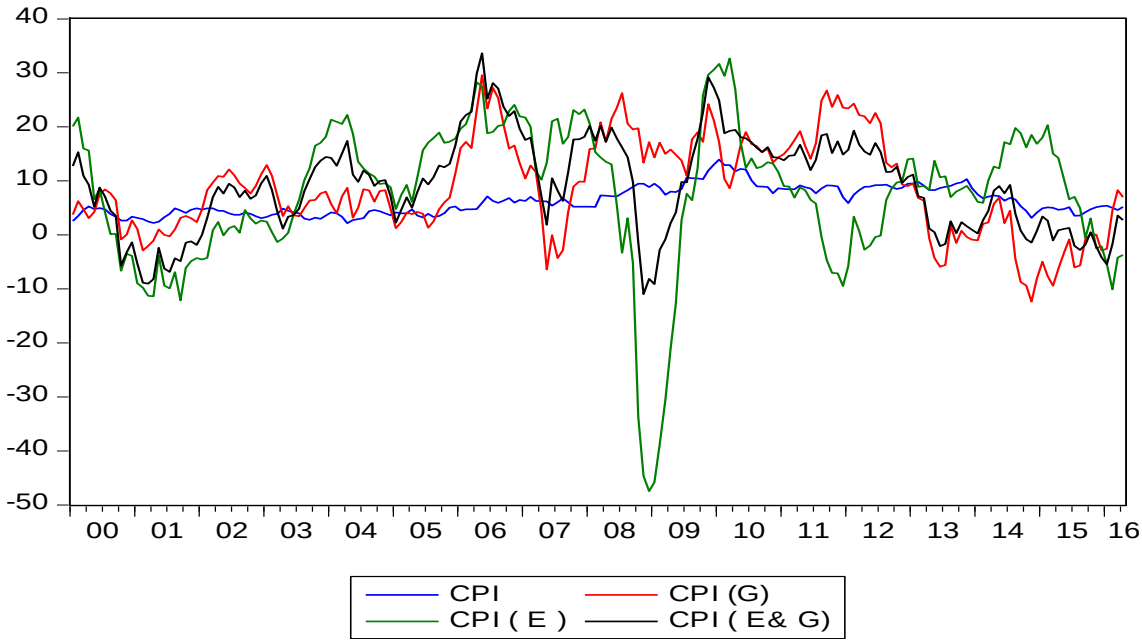


Figure 4.3: Inflation after Including Asset Prices into Consumer Price Index
Source: Author's Calculation

The above figure 4.8 presents the inflation after including asset price i.e. gold and equity into the consumer price index after assigning to different weight to it. Including equity to the consumption basket making the inflation highly volatile.However, it has a high impact on inflation if equity price gets fluctuated. While inclusion of gold price into consumption basket is comparatively less volatile to inclusion of equity price in to the consumption basket. Inclusion of both gold and equity is also comparatively less volatile than only inclusion of equity in to the consumption basket.

After getting the respective inflation series after including gold and equity price into the consumption basket, we proceed for in sample forecasting by using Kalman filter. Our main objective behind including asset price into the consumption basket and estimating core inflation is to get a better prediction of inflation.

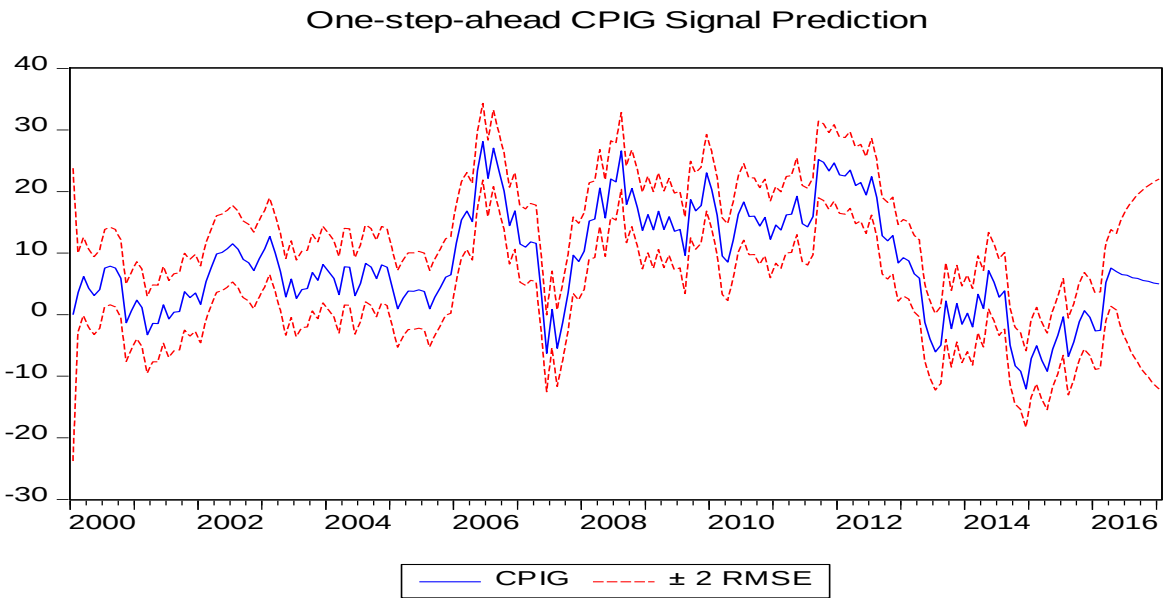


Figure 4.4: Forecasting of CPI Gold
Source: Author's Calculation

The above figure 4.4 presents the in sample forecasting of CPI inflation including gold as a commodity into the price index.

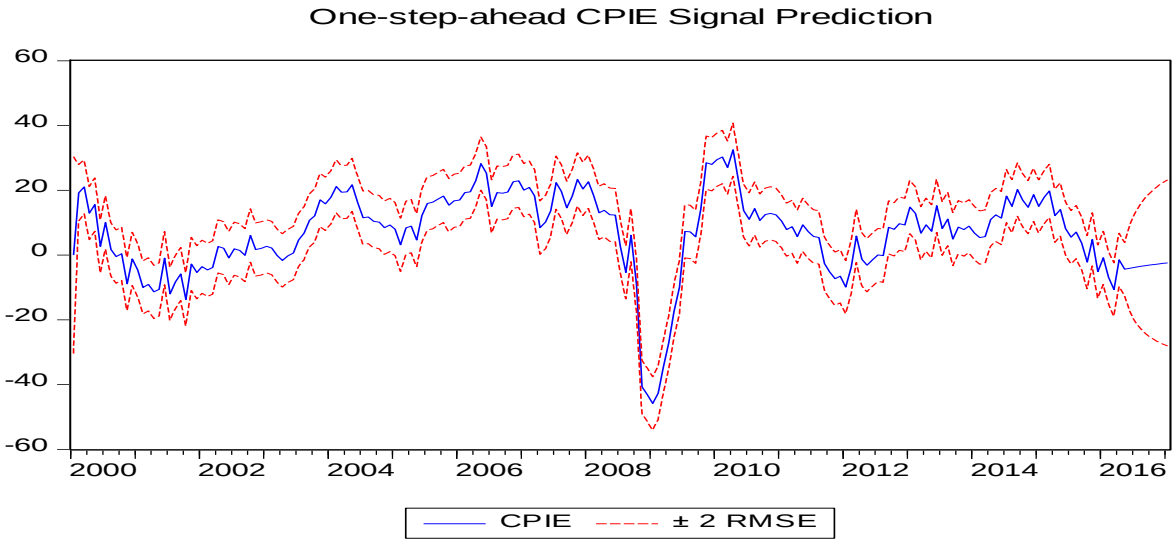


Figure 4.5: Forecasting of CPI Equity
Source: Author's Calculation

The above figure 4.5 presents the in sample forecasting of inflation after including equity price in to the consumption index.

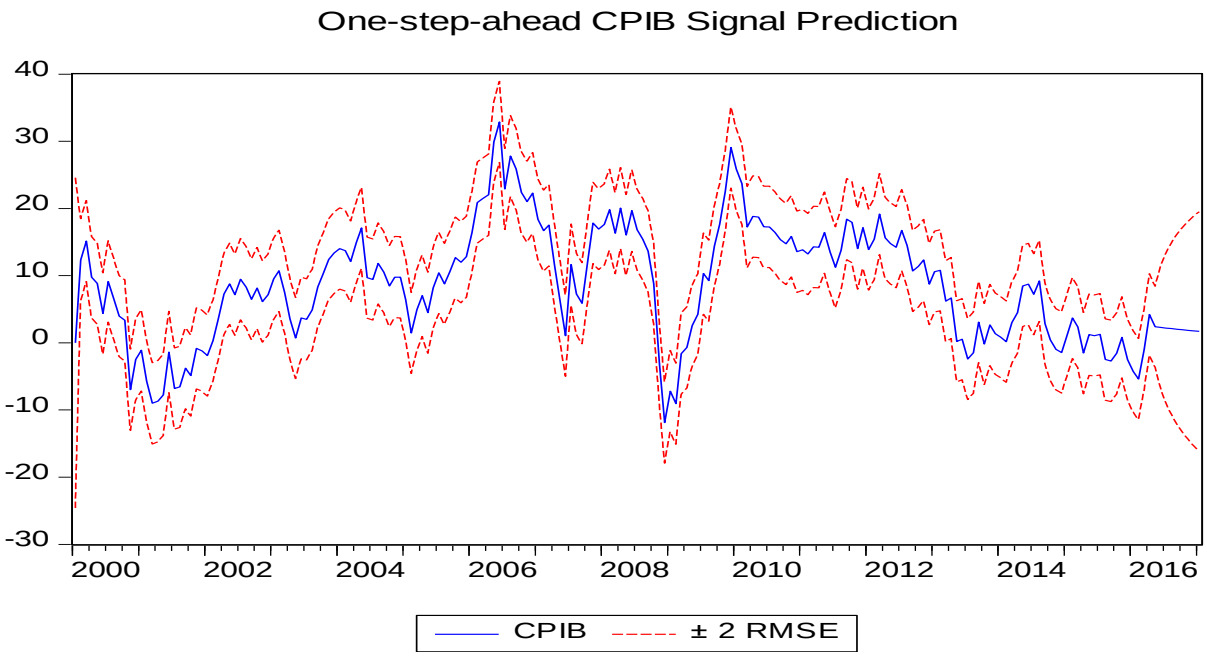


Figure 4.6: Forecasting of CPI both Equity and Gold
Source: Author's Calculation

Figure 4.6presents the in sample forecasting of inflation after simultaneously including both gold and equity price as a commodity in to the consumption basket. Three figures (4.4, 4.5, and 4.6) above presents the sample forecasting of inflation after including gold and equity to the consumption basket. Among all the three measures CPI with gold outperforms in forecasting the level of inflation than other two measures. So, CPI gold can be considered to keep an eye while conducting monetary policy. In India, it is mostly demanded asset to be invested and import of gold highly affects the Indian economy.

4.5. Conclusion

As we know people's consumption habits depend on future expectations, we must consider this expectations and investment for the future while estimating the level of inflation. Our monetary policy also operates with lag, considering people's expectation, which help in an easy conduct of monetary policy, maintaining transparency and credibility. Therefore, our study aims to considering asset price (gold and equity) as a commodity of consumption basket and then estimated inflation. We also check the

predictability of these inflation series. Wefind that, considering gold as commodity of consumption basket helps in predicting better level of inflation. But here problem is that, asset prices are highly fluctuating; they are more volatile than the items in normal consumption baskets of individuals. Therefore, we cannot react to all the movements of asset prices. If any movements in asset prices signalling any inflationary or deflationary situation then, then only monetary policy must react to asset price movements. That means we have to find out the misalignments of asset prices.

Chapter 5

Impact of Core Inflation on Macroeconomic Performance in India

5.1. Introduction

The monetary policy framework of inflation targeting was get popularised after New Zealand announces them as inflation targeting in 1990. Officially announcing a country as inflation targeting means; central bank of that country has only one objective i.e. maintaining price stability. Generally, central bank of a country has multiple objectives such as to achieve economic growth, stable exchange rates and tomanage foreign exchange reserves etc. In this scenario, achieving all the objectives all together is too difficult. Because, monetary policyfaces the problem of impossible trinity or problem of trilemma. Monetary policy has to manage the trade-off between inflation and economic growth with other objectives. Hence, it is better to set only one objective which create a base for overall economic development. Inflation targeting does that with only one objective of price stability i.e. maintaining a low level of inflation. It is believed that, price stability is the pre-condition for sustained economic development from every aspect. A high level of inflation adversely affects the economy in the long run. Normally inflation gets affected by short-term temporary fluctuations. Conducting monetary policy in response to these temporary fluctuations is not possible.To address this problem, the term core inflation is coined which ignored these temporary supply side fluctuations. While targeting core inflation, it excludes some fluctuations in economy. So, the question is how it ultimately affects the macroeconomic performance of a country. To manage the level of inflation, monetary policyuses short-term interest rate as an instrument. Change in interest rate affects the effective demand of the economy, which ultimately affects output through investment and consumption. It also affects exchange rate by appreciation/depreciation of the domestic currency.

Although adoption of inflation targeting leads to fall in inflation rate in the countries who initiated the inflation targeting framework and followed core inflation the unemployment rate become higher. This is characteristics of the Phillip's curve. If we are targeting core inflation, we should manage the trade-off between inflation and unemployment rate to achieve a low and stable rate of inflation with the cost of high unemployment rate.

To achieve the low and stable inflation under inflation targeting framework, generally central banks uses interest rate as an instrument. Finally, when it is passed by commercial banks, it reduces the demand for credit that lowers the investment and output growth. If potential investors assume that the lower level of inflation in the economy means prevailing of depressed aggregate demand in the economy and it is going to continue in the future, they will postpone their investment plans and which will lead to a slower economy even if it is not a depressed economy.

It is very difficult to find, if any monetary policy able to control a high level of inflation without slow down effect in the economy. A lower level of growth in an economy triggers the capital outflow later leads to a weaker currency and also a reason for stagflation. Being a developing country, number of poor heads in India is more. Both the problem of inflation and lower growth highly affects them. If government really want to solve these problems, then they mustfocus on solve the problem of food supply and its proper distribution instead of fighting with inflation.

This study aims to examine,empirically, the changes in macroeconomic performance of Indian economy if it follows core inflation instead of headline inflation. Without thinking if following core inflation improves macroeconomic performance or not. According to earlier studies, inflation targeting has a positive impact only on the economy of developing countries.It does not contribute much to the economy of developed countries.

5.2. Review of Literature

Levin, Natalucci,& Piger (2004)examined themacroeconomic effects of inflation targeting for industrialised countries. The study also compares the macroeconomic performance of both the inflation targeting and non-inflation targeting countries. Adoption of inflation, targeting in industrialised countries, is not associated with an instantaneous adjustment of inflation expectations; but in case of emerging economies, it has succeeded in reducing average inflation to very low levels. Similarly, Pétursson (2004) examined the economic effects of inflation targeting. The new inflation targeting framework has improved the credibility of central banks. This makes it easier for the central bank to achieve its goal with smoother adjustments in policy stance. Carrasco & Ferreiro (2011) examined the economic performance of Mexico after adopting inflation targeting; and as a result, the study finds that inflation targeting leads to decrease in the level of inflation and its variability in Mexico.

Rochon & Rossi (2006) intended to find out the impact of inflation targeting on distribution of income, specifically to the wage share. Theyfound that, it is often seen that sacrifice ratio is high after adopting inflation targeting, and income distribution for wage earners has worsened. This leads to drop in effective demand and ultimately it has a negative impact on the output and employment.

Libânio (2010)examined theeconomic performance of Brazil during inflation targeting period i.e. 1999 to 2006. The study aims to find out the channel of transmission between inflation targeting to growth through aggregate demand. Because under inflation targeting, monetary policy functions in a procyclical and asymmetric way to fluctuation in economic activity. This behaviour of monetary policy affects growth and employment negatively. As an empirical result the study finds that monetary policy in Brazil behaves in both procyclical and asymmetric way which leads to negative effect on aggregate demand and growth.

Ben Romdhane & Mensi (2014) assessed the macroeconomic effect of inflation targeting, specifically on output in OECD economies. The study uses “differences-in-

differences" approach by Ball and Sheridan (2005) on a panel data of 30 OECD countries from the period of 1980 to 2012. As a result, the study finds that, inflation targeting improves the macroeconomic performance of the country than non-inflation targeters. Another study byDaboussi (2014) examined the macroeconomic effect of inflation targeting, specifically on inflation, output growth and interest rate. This study also uses "differences-in-differences" approach of Ball and Sheridan (2005) to analyse the impact of inflation targeting on economy of 53 developing countries from the period of 1980-2012. The effect of inflation targeting on economic performance of developing countries is significant.

Ftiti (2005) proposed a new methodology to check the macroeconomic performance of monetary policy, particularly the impact of inflation targeting framework. The main aim of inflation targeting framework is to maintain a stable economy. An economy is considered to be stable when a long run equilibrium exists to which the paths of economic variables (inflation rate, Interest rate and GDP growth) converge. The newly proposed method by the author targets to measure the degree of convergence between economic variables and as a result the study finds that monetary policy framework of inflation targeting creates stable monetary environment and reduce the level of uncertainty in the economy.

Siklos (1999) examined whether adopting inflation targeting monetary policy framework actually improves the performance of overall inflation in industrial countries or not. Adopting inflation targeting is not sufficient enough in delivering consistently better inflation performance nor in significantly influencing inflation expectations.It remains to be seen whether inflation targeting can tolerate pressures stemming from sustained breaches of their targets should inflation policies in the major industrialized countries begin to diverge.

Kohli (2015) analysed the inflation framework for India. Recently, India adopted inflation targeting framework with target of 4% with ±2% band after the Urjit Patel Committee Report. According to the author, there are some risks in adopting inflation

targeting in recent macroeconomic scenario of India. The'Urjit Patel Committee Report' was silent and non-transparent about the disinflation costs during the transition to FIT. Although these were balanced against the speed of disinflation to reach the medium-term inflation target, the estimated declines in Gross Domestic Product (GDP) in the process were not published. If supply-side responses are not forthcoming in conjunction with the low-growth conditions at the time of transition to FIT, the economy could be trapped in a vicious circle, breaking out from which could be difficult due to fear of undermining policy credibility. Strong institutional support is essential for IT. The most fundamental support is from fiscal policy due to its close and immediate relationship with aggregate demand.

Achnab (2016) examined whether an emerging country can follow both exchange rate and inflation targeting regime to improve macro-economic performance of an economy. To examine this, the study uses sample of 28 emerging countries, from the period of 1985 to 2000. As a result, the study finds that exchange rate regime improves the performance of growth and decreases the level of inflation. Inflation targeting regime can be used as a complimentary to the flexible exchange rate regime and as a substitute for a fixed exchange rate regime.

Mishkin and Schmidt-Hebbel (2007) tried to find outwhether adopting inflation targeting really make any difference to the economy or not. The study finds that inflation targeting helps countries in achieving low inflation in the long run and have a smaller inflation response to exchange rate and oil price shocks; but still the macroeconomic performance of inflation targeting and non-targeting does not have much difference. The performance attained by industrial-country, inflation targeters generally dominate performance of emerging-economy inflation targeters and issimilar to that of industrial non-inflation targeting countries.

5.3. Inflation and its Impact on Macroeconomic Variables

In layman point of view, generally inflation has negatively related to the macroeconomic variables. Macroeconomic variables are more responsive to inflation; in high inflation regime than low inflation regime. In this section, we discuss inflation and its impact on macroeconomic variables such as export, exchange rate and output.

Inflation and Net Export

Fluctuations in the level of inflation affect the comparative prices of import and exports of a country. Rising in the domestic inflation of a country leads to rise in the cost of exports. Prices of goods that are exported increases, as foreign consumers pay a higher price for imported goods from a country with higher level of domestic inflation. Then the foreign consumers may shift to lower price substitute goods.Similarly, if domestic inflation of a country decreases the relative price of its exports declines and the price of imported goods rises.

The basic rule is that higher the domestic level of inflation rate relative to other trading countries leads to decrease in net exports i.e. increases the relative price of imports. Lower domestic level of inflation in comparison to other trading countries leads to decrease in relative prices of exports and increase in the relative prices of imports. While targeting core inflation and aiming to maintain a low and stable level of inflation means: there will be increase in net export i.e. decrease in the relative prices of exports and increase in the relative prices of imports.

Inflation and Exchange Rate

Inflation has a significant negative impact on a country’s currency value or foreign exchange rate. A low level of inflation does not guarantee a favourable rate of exchange but a high level of inflation has an adverse impact on a country’s exchange rate. To manage the level of inflation we use interest rate as an instrument and interest rate can highly affect the exchange rate. A higher level of interest rates tends to attract foreign investors, which increases the demand for a country's currency. However, a higher rate of interest often causes anincrease in inflation rates and negativelyaffects the country's

currency. Low interest rates spur consumer spending and economic growth, and generally positively influence currency value; but they do not commonly attract foreign investments.

Inflation and Output

A layman point of view, inflation always affects economic growth negatively, but this is not true always. Existence of mild inflation is necessary for the growth of an economy than hyperinflation. A low level of inflation affects the growth rate of the economy positively or remains neutral over a period. When inflation is exceeding from certain level, i.e. high level of inflation which affects the growth negatively, affects the other macro-economic variables such as interest rate, exchange rate and money supply. This type of relationship growth and inflation are nonlinear and the level of inflation beyond which inflation affects the growth negatively is known as 'threshold level of inflation'. The objective of every central bank is to maintain the threshold level of inflation.

5.4. Data and Methodology

To study the macroeconomic performance of core inflation measures of the Indian economy, we have consideredall the different measures of core inflation we estimated in our study i.e.trimmed mean measure of core inflation, tradable and non-tradable inflation. Which have already estimated in the earlier chapter-third and the level of inflation including gold and equity into the consumption basket.In this study, we have considered macroeconomic variables such as Index of Industrial Production (IIP) as a proxy to GDP, Real Effective Exchange Rate (REER), interest rate, broad money and net trade. Theoretically, we discuss the different measures of core inflation below:

Trimmed Mean Measure of Core Inflation

In this measure, core inflation constitutes a weighted average of price changes after excluding some percentage of volatility from both the tails. So, it is also known as trimmed mean measure. This trimmed mean measure can be calculated by two ways: (a) symmetric trimmed mean and (b) asymmetric trimmed mean. In symmetric trimmed

mean we trimmed equal percentage from the both tails, but in case of asymmetric trimmed mean we trimmed different percentage according to the presence of skewness and kurtosis presents in the series. However, this study is limited to the symmetric trimmed mean measure. We have used 25% trimmed mean measure to calculate core inflation.

Tradable and Non-Tradable Inflation

As we know for estimation of core inflation, we need to exclude volatile commodities from the price index, but only different commodities nature does not lead to fluctuations in the inflation level. There are other external factors are there which leads to temporary fluctuations in the inflation level. Therefore, we estimated inflation by decomposing headline inflation into tradable and non-tradable. Tradable inflation is highly associated with external sector fluctuation while non-tradable inflation represents purely domestic inflation.

Rate of Inflation after Including Asset Price

One of the important properties and reason behind estimating core inflation is to predict the future level of inflation. Normally people live in two periods, such as, current and future. So, they plan for future and invest for future. While conducting monetary policy we must consideredpeople's expectation. Asset prices are better predictor for these behaviours of people and future expectations. So, while targeting inflation we must keep an eye on movements of asset prices. Therefore, we have constructed inflation including gold and equity price in the consumer price index.

After estimating all the measure of core inflation,we have tested whether any of these measures improves the macroeconomic performance of the economy or not. To study the macroeconomic scenario, we have considered, net trade (Export-Import), Real Effective Exchange Rate (REER), Broad Money (M3) and GDP. As monthly data of GDP is not available, we used Index of Industrial Production (IIP) as proxy of GDP.

Before any time, series analysis, first we need to conduct the unit root test to know whether the variables are stationary or not and then we can proceed to conduct the co-integration test. We found that all the variables are stationary at first difference and co-integrating vector exist between variables. Further, we can proceed our empirical analysis with Vector Error Correction Model (VECM).

5.5. Empirical Results and Discussion

In the unit root test of the variables, we find that all the variables i.e. all the series of core inflationand macroeconomic variablesare stationary at first difference. All the variables are non-stationary at the level i.e. we cannot reject the null hypothesis of presence of unit root. Then we converted all the variables to first difference and found all the variables are stationary at first difference and integrated of order one, i.e., I (1) process and now we can reject the null hypothesis of presence of unit root. The result of unit root test has presented in table 5.1.

Table 5.1
Unit Root Test Result (ADF Test without Trend)

Variables	t-statistics	P Value
At Level		
Trim Core Inflation (CPI)	-1.83	0.36
Tradable Inflation	-2.46	0.12
Non-tradable Inflation	-2.08	0.25
CPI including Gold	-2.58	0.09
IIP	-2.74	0.06
Net Trade	-1.78	0.38
REER	-2.41	0.13
Call Money Rate	-2.26	0.06
Broad Money	8.22	1.00
First Difference		
Trim Core Inflation (CPI)	-13.60	0.00
Tradable Inflation	-11.95	0.00
Non-tradable Inflation	-14.21	0.00
CPI including Gold	-13.16	0.00
IIP	-22.62	0.00
Net Trade	-14.40	0.00
REER	-12.35	0.00
Call Money Rate	-12.84	0.00
Broad Money	-6.90	0.00

*Note: * indicates the tabulated value at 5% level of significance i.e., -3.42.*
Source: Author's Calculation

After unit root test, we also checked the possibility of presence of co-integration among variables by conducting Johanson Juselius test of co-integration. But, as a result we find existence of one co-integrating vector among variables. We further proceed our analysis with Vector Error Correction Mechanism (VECM). The objective of this study is to find out the macroeconomic performance of the economy, specifically growth in monetary policy functions keeping in mind core inflation rather than headline inflation. India hasrecently started targeting inflation and we cannot check the macroeconomic performance pre- and post-inflation targeting. Therefore, we examine the effect of core inflation on macroeconomic variables by looking into impulse response function from VECM. We examine the macroeconomic impact of four different measures of core inflation i.e. trimmed mean measures of core inflation (CPI), tradable inflation, non-tradable inflation and inflation including as a commodity to price indexis presented as the following:

Trim Core Inflation (CPI) and Its Impact on the Economy

First, we examine the impact of trim_core inflation on the macroeconomic variables of India. Whether following trim_core measure as a measure of core inflation improves the macroeconomic performance of India or not? We have already tested the sationarity of the variables and found that all the variables are stationary at the first difference. We also checked the possibility of presence of co-integration among variables by conducting Johanson Juselius test of co-integration and found that there is one co-integrating vector exists among variables and the result of co-integration has been given in table A2 in appendix. As we found the presence of co-integrating relationship between variables, we proceed for VECM analysis and analyse the impulse response function and variance decomposition. We also checked the stability of the VEC model, by testing AR root graphs, which shows that VEC model stratifies the stability conditionand the result is given in figure A2 in appendix.

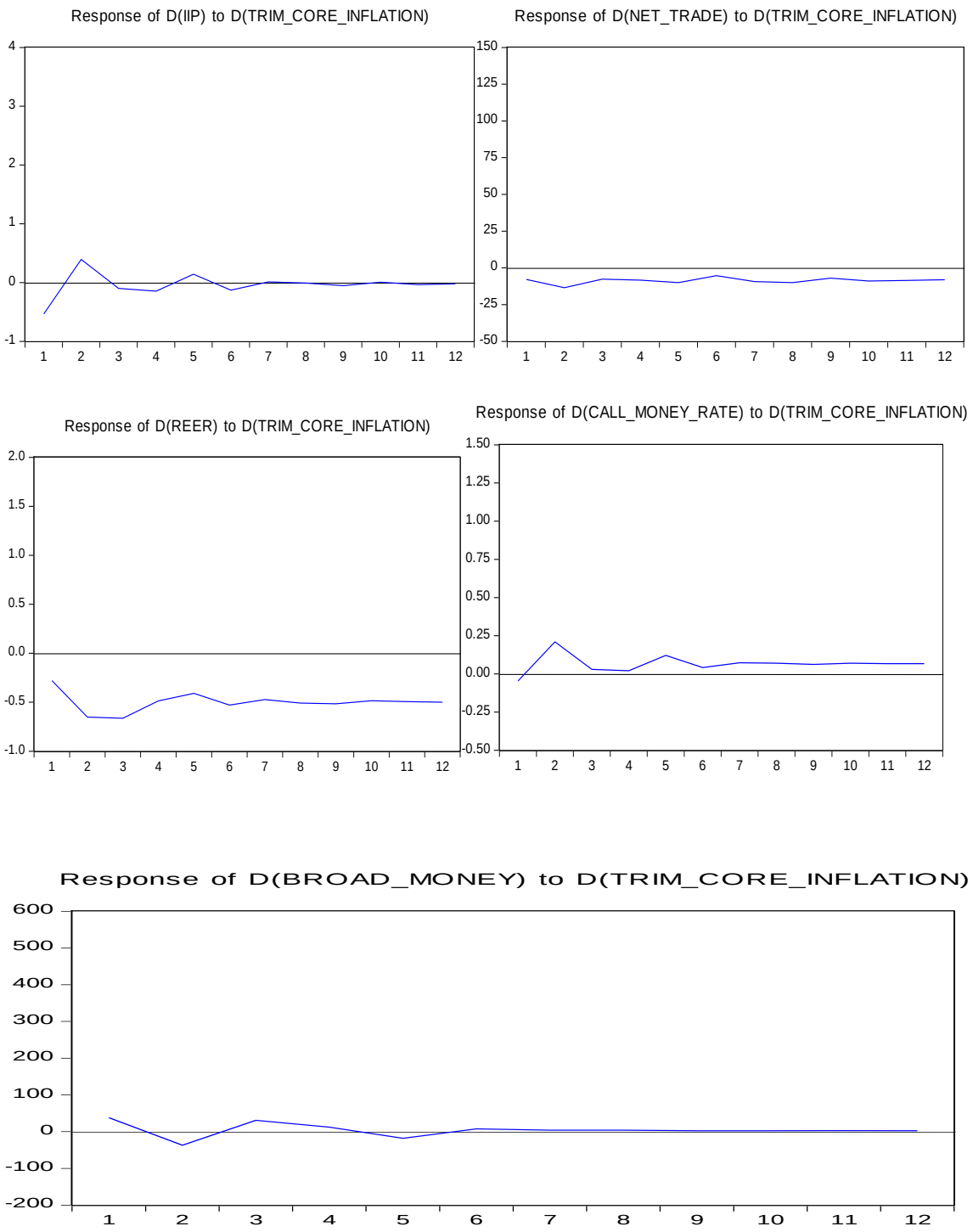


Figure 5.1: Impulse Response Function of Macroeconomic Variables to One Standard Deviation of Trim Core (CPI) Measure of Core Inflation
Source: Author's Calculation

The above figure 5.1presents the impulse response function of various macroeconomic variables in response to the one standard deviation shock to the trim core (CPI) inflation. In response to the one standard deviation shock to the trim core inflation leads to a positive rise in IIP. We have taken IIP as proxy to GDP. Our general idea is that inflation has a negative impact of growth but it has a negative effect after a threshold level of inflation. Below that threshold level, inflation has a positive or zero impact on growth. When a country follow inflation targeting framework it aims to maintain that threshold level of inflation for theeconomy. Hence, shock to the trim core inflation immediately has a positive impact because of that threshold level of inflation, but after that it starts to fall and fluctuate. Any shock to the trim core inflation leads to rise in call money rate; after second period it starts to decline, after third period it remain stable for one period and then it again starts fluctuate up to seventh period. While broad money and exchange rate has a negative effect of shocks to trim core inflation. But, these effects die out after fifth period. While net trade does not affect much by shocks to the core inflation.

Table 5.2
Result of Variance Decomposition

Variance Decomposition of D(Trim Core Inflation CPI)							
Period	**S.E.**	**D(Trim Core Inflation CPI)**	**D(IIP)**	**D(REER)**	**D(Net Trade Balance)**	**D(Interest Rate)**	**D(Broad Money)**
1	0.51304	100	0	0	0	0	0
2	0.58358	91.9718	0.05789	4.43135	2.65854	0.7998	0.08066
3	0.64386	90.6717	0.73547	3.70415	3.33792	0.83698	0.71379
4	0.71396	90.2696	0.62199	4.009	3.76066	0.68432	0.65443
5	0.77339	90.6666	0.54673	4.01566	3.35117	0.85779	0.56203
6	0.82509	90.5575	0.51204	3.79394	3.77094	0.8206	0.545
7	0.87483	90.7695	0.45571	3.73427	3.72507	0.77128	0.54412
8	0.92222	90.6819	0.45442	3.80163	3.71424	0.83197	0.51585
9	0.96684	90.7536	0.41789	3.7219	3.81684	0.79781	0.49193
10	1.01022	90.7903	0.38692	3.7093	3.83335	0.7823	0.49782
11	1.05096	90.8379	0.37451	3.69478	3.81253	0.80198	0.4783
12	1.09047	90.882	0.35109	3.66506	3.85097	0.78248	0.46844
Variance Decomposition of D(IIP)							
Period	**S.E.**	**D(Trim Core Inflation CPI)**	**D(IIP)**	**D(REER)**	**D(Net Trade Balance)**	**D(Interest Rate)**	**D(Broad Money)**
1	3.14581	2.88	97.12	0	0	0	0
2	3.1782	4.36169	95.2827	1.56E-06	0.29678	0.00211	0.05668
3	3.6131	3.44934	95.2568	0.32002	0.42754	0.44285	0.10347
4	3.88176	3.13091	94.8968	0.41223	0.55029	0.82682	0.18292
5	3.97849	3.11009	94.5888	0.43903	0.5382	1.10947	0.21444
6	4.26238	2.80147	95.1575	0.39914	0.469	0.96683	0.2061
7	4.40132	2.62822	95.3799	0.37766	0.47111	0.946	0.19709

8	4.56167	2.44695	95.5129	0.37606	0.44024	1.03303	0.19088
9	4.74318	2.27514	95.7961	0.3493	0.41655	0.9746	0.18835
10	4.87895	2.15047	96.0062	0.33129	0.40633	0.92763	0.17809
11	5.03361	2.02505	96.2109	0.31894	0.38428	0.89347	0.16738
12	5.18009	1.91377	96.4026	0.30257	0.37292	0.84644	0.16167
Variance Decomposition of D(REER)							
Period	**S.E.**	**D(Trim Core Inflation CPI)**	**D(IIP)**	**D(REER)**	**D(Net Trade Balance)**	**D(Interest Rate)**	**D(Broad Money)**
1	1.81088	2.36886	0.36821	97.2629	0	0	0
2	2.05158	11.9452	0.35908	83.6664	0.59241	0.89949	2.53741
3	2.35474	16.9964	9.65058	66.8353	3.74532	0.812	1.96038
4	2.62913	17.054	8.57964	58.091	13.2505	0.65148	2.37347
5	2.76363	17.6211	8.65827	56.8576	12.8066	0.65461	3.40179
6	2.92614	18.9803	9.36723	55.3201	12.3444	0.8023	3.18559
7	3.08555	19.4242	8.88441	54.8463	12.9805	0.72155	3.14304
8	3.2334	20.1605	9.28733	53.0828	13.3519	0.73111	3.38647
9	3.37385	20.86	9.56611	51.8972	13.5628	0.77144	3.34239
10	3.50627	21.2198	9.46569	51.1183	14.0449	0.71766	3.43362
11	3.63375	21.5999	9.62445	50.4118	14.1474	0.72998	3.48645
12	3.75621	21.9867	9.68182	49.8634	14.2479	0.7308	3.48932
Variance Decomposition of D(Net Trade Balance)							
Period	**S.E.**	**D(Trim Core Inflation CPI)**	**D(IIP)**	**D(REER)**	**D(Net Trade Balance)**	**D(Interest Rate)**	**D(Broad Money)**
1	132.495	0.34975	0.47244	10.6326	88.5452	0	0
2	139.261	1.25871	2.01331	12.8603	80.1511	0.00121	3.71541
3	144.18	1.4574	2.03026	14.1677	78.179	0.69702	3.46862
4	160.915	1.44256	2.83813	19.1777	72.9054	0.78903	2.84714
5	167.819	1.68011	3.14505	19.6293	70.7324	0.80437	4.00875
6	173.78	1.66019	2.9962	20.7095	69.9631	0.93243	3.73866
7	183.215	1.75273	3.51762	21.7157	68.6215	0.89185	3.50055
8	189.528	1.91811	3.60665	22.55	67.5046	0.88122	3.53941
9	195.431	1.93083	3.62687	23.4698	66.7171	0.89064	3.36484
10	202.557	1.99221	3.84801	24.1302	65.935	0.83417	3.26041
11	208.515	2.04835	3.86685	24.681	65.3859	0.82106	3.19687
12	214.243	2.08339	3.9322	25.2706	64.8156	0.79796	3.10028
Variance Decomposition of D(Interest Rate)							
Period	**S.E.**	**D(Trim Core Inflation CPI)**	**D(IIP)**	**D(REER)**	**D(Net Trade Balance)**	**D(Interest Rate)**	**D(Broad Money)**
1	1.38858	0.10898	1.1465	0.11655	0.12283	98.5052	0
2	1.41916	2.299	1.21382	0.66566	0.80275	94.6128	0.40599
3	1.55324	1.95591	1.92873	0.59286	0.67113	94.3009	0.55046
4	1.729	1.59284	1.55662	0.67853	1.25167	94.3819	0.53849
5	1.7802	1.96475	1.6661	0.74803	1.21391	93.5792	0.82801
6	1.89178	1.78732	1.60567	0.79333	1.14512	93.9134	0.75516
7	1.98621	1.75566	1.47516	0.78947	1.31	93.9775	0.6922
8	2.05343	1.75993	1.55743	0.84685	1.27473	93.8339	0.72713
9	2.1415	1.70316	1.47735	0.86469	1.2596	94.0079	0.68726
10	2.21818	1.68815	1.43652	0.87957	1.32612	94.0037	0.6659
11	2.28664	1.6741	1.44023	0.90397	1.29942	94.0215	0.66083

12	2.36166	1.64902	1.39416	0.91878	1.30681	94.0915	0.63971
Variance Decomposition of D(Broad Money)							
Period	**S.E.**	**D(Trim Core Inflation CPI)**	**D(IIP)**	**D(REER)**	**D(Net Trade Balance)**	**D(Interest Rate)**	**D(Broad Money)**
1	513.642	0.55052	0.47379	0.42457	0.43993	1.00589	97.1053
2	552.186	0.92695	0.41325	0.83322	6.5549	1.07092	90.2008
3	620.869	0.97914	0.65779	1.14013	10.7497	0.95101	85.5222
4	674.632	0.86363	0.55714	1.38139	11.0131	0.90848	85.2762
5	721.227	0.81859	0.49786	1.30886	11.9519	1.12475	84.2981
6	767.726	0.73232	0.44086	1.24695	12.2591	1.04423	84.2765
7	808.635	0.66265	0.39782	1.24094	12.5152	1.03455	84.1489
8	851	0.60058	0.36076	1.25104	13.1532	1.0891	83.5453
9	889.502	0.55038	0.33162	1.25792	13.4514	1.05474	83.3539
10	926.187	0.50827	0.30621	1.26141	13.6823	1.06289	83.179
11	962.185	0.47195	0.28398	1.25187	13.9147	1.07178	83.0058
12	996.401	0.44066	0.26538	1.24997	14.09	1.05971	82.8943
Cholesky Ordering: D(Trim Core Inflation CPI) D(IIP) D(REER) D(Net Trade Balance) D(Call Money Rate) D(Broad Money)							

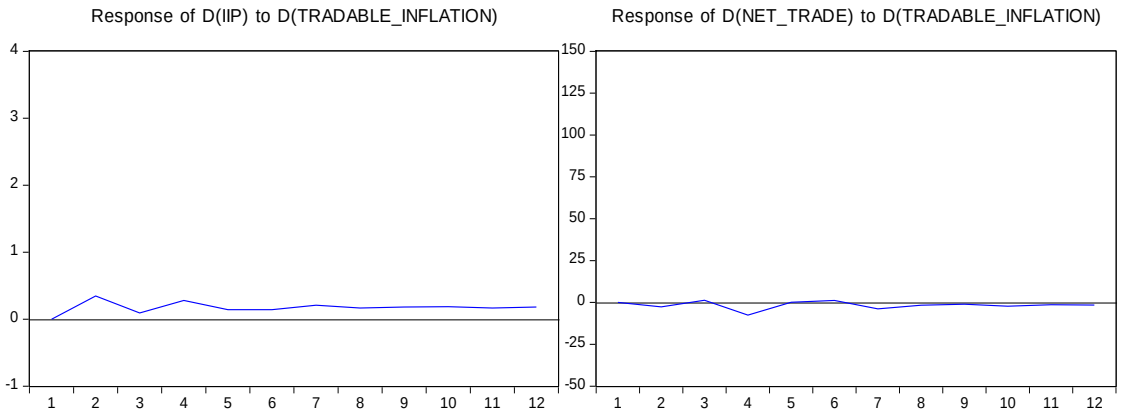
Source: Author's Calculation

The above table 5.2 presents the result of variance decomposition of trim_core inflation, IIP, REER, net trade balance, call money rate and broad money. Initially, variation in trim_core inflation is explained 100 percent by its own shock but by the end of twelfth month 90 percent of variation explained by its own shock and around 3 percent of variation is explained by other variables such as tradable REER and net trade balance. In case of IIP, around 97 percent of variation explained by its own shock and 2 percent of variation explained trim_core inflation and same continue up to twelfth period. While in case of REER, initially 97 percent of variation explained by its own shock and 2 percent of variation explained by trim_core inflation. By the end of twelfth month around 49 percent of variation explained by its own shock and 14 percent of variation explained by net trade balance, 9 percent variation explained by IIP and around 3 percent of variation explained broad money. In case of broad money, initially around 97 percent of variation explained by its own shock and 1 percent of variation explained by interest rate. By the end of twelfth month 82 percent of variation explained by its own shock, 14 percent of variation explained by net trade balance and around 1 percent of variation explained by REER and interest rate. In case of net trade balance, around 88 percent of variation explained by its own shock and 10 percent variation explained by REER and by the end of twelfth month around 64 percent of variation explained by its

own shock, 25 percent of variation explained by REER. In case of interest rate, 97 percent of variation explained by its own shock and 1 percent of variation explained by interest rate. By the end of twelfth month 82 percent of variation explained by its own shock and 14 percent of variation explained by net trade balance and around 1 percent of variation explained by REER and interest rate respectively.

Tradable Inflation and Its Impact on the Economy

Further, we examine the impact of tradable inflation on the macroeconomic variables of India. Whether following tradable inflation measure as a measure of inflation improves the macroeconomic performance of India or not? We have already tested the sationarity of the variables and found that all the variables are stationary at the first difference. We also checked the possibility of presence of co-integration among variables by conducting Johanson Juselius test of co-integration and found that there are two co-integrating vector exists among variables and the result of co-integration given in table A4 in appendix. As we found the presence of co-integrating relationship between variables, we proceed for VECM analysis and analyse the impulse response function and variance decomposition. We also checked the stability of the VEC model, by testing AR root graphs, which shows that VEC model stratifies the stability condition and the result is given in figure A3 in appendix.



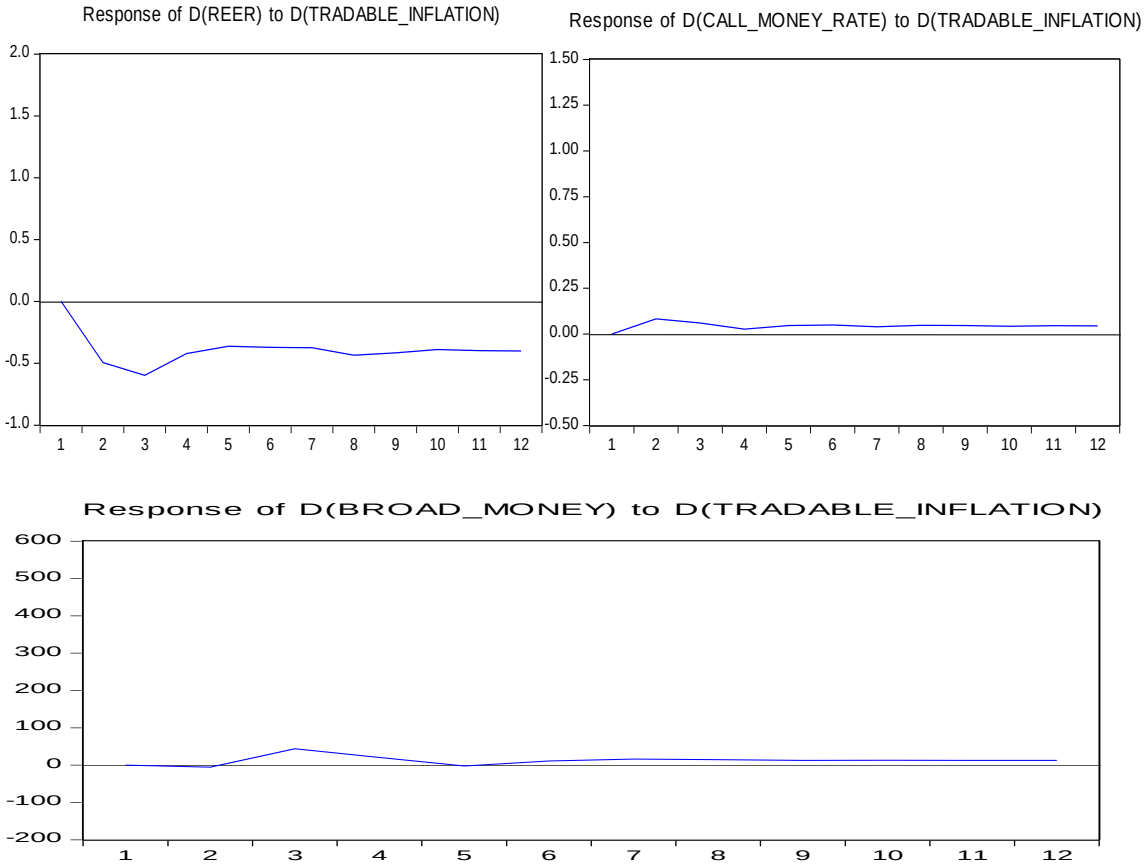


Figure 5.2: Impulse Response Function of Macroeconomic Variables to One Standard Deviation of Tradable Inflation
Source: Author's Calculation

Figure 5.2 presents the impulse response function of various macroeconomic variables in response to the one standard deviation shock to the tradable inflation. In response to the one standard deviation shock to the trim core inflation leads to a positive rise in IIP. But, the effect dies out after fifth period. Up to fifth period, it follows a cyclical path. Shock to tradable inflation has a large impact on REER. REER has immediately started to fall in response to the one standard deviation shock to the tradable inflation up to the third period, after the third period it rise up to the fourth period and remain stable at that level. Net trade affected negatively in between only the third to fourth period while broad money was affected positively in between the second and the fourth period. Interest rate rises up to the second period, and then falls from the second to the fourth period and become stable after that.

Table 5.3
Result of Variance Decomposition

Variance Decomposition of D(Tradable Inflation)							
Period	**S.E.**	**D(Tradable Inflation)**	**D(IIP)**	**D(Net Trade Balance)**	**D(REER)**	**D(Interest Rate)**	**D(Broad Money)**
1	1.027074	100	0	0	0	0	0
2	1.160371	97.11535	0.013348	0.217351	2.164453	0.250249	0.239249
3	1.235967	95.15007	1.094187	0.403773	2.372069	0.495625	0.484278
4	1.36364	91.82826	2.089422	0.804061	4.385816	0.42531	0.467132
5	1.473557	91.91987	1.844662	0.729336	4.659826	0.445048	0.401257
6	1.568081	91.84622	1.833969	0.818983	4.663892	0.439172	0.397764
7	1.656907	91.89468	1.842699	0.824283	4.663763	0.411015	0.363561
8	1.741581	91.6098	1.882578	0.821544	4.926988	0.419658	0.339428
9	1.822044	91.37485	1.949232	0.880627	5.074694	0.401199	0.319403
10	1.89982	91.28664	1.939328	0.895466	5.180658	0.389045	0.308867
11	1.974343	91.22166	1.949221	0.893257	5.253435	0.388557	0.293867
12	2.046081	91.159	1.960303	0.911961	5.308848	0.379175	0.280716
Variance Decomposition of D(IIP)							
Period	**S.E.**	**D(Tradable Inflation)**	**D(IIP)**	**D(Net Trade Balance)**	**D(REER)**	**D(Interest Rate)**	**D(Broad Money)**
1	3.098244	2.972564	97.02744	0	0	0	0
2	3.162669	4.214066	93.77507	0.550278	1.078895	0.003841	0.377846
3	3.472722	3.681473	94.07795	0.457336	0.937978	0.491505	0.35376
4	3.731482	3.195494	91.92247	0.614564	2.660563	0.908511	0.698396
5	3.810398	3.065502	91.81645	0.687432	2.55415	1.205705	0.670757
6	4.044184	2.789493	92.39902	0.636306	2.438611	1.072612	0.663957
7	4.168833	2.628576	92.42932	0.676806	2.550791	1.033294	0.68121
8	4.294821	2.478928	92.52846	0.720602	2.510656	1.111621	0.649733
9	4.449461	2.315032	92.72382	0.711746	2.538168	1.044167	0.667069
10	4.567527	2.196918	92.82582	0.748319	2.568445	0.998335	0.662161
11	4.69658	2.083334	93.01064	0.753372	2.539267	0.969047	0.644337
12	4.823061	1.977017	93.13335	0.761305	2.556918	0.919171	0.65224
Variance Decomposition of D(Net Trade Balance)							
Period	**S.E.**	**D(Tradable Inflation)**	**D(IIP)**	**D(Net Trade Balance)**	**D(REER)**	**D(Interest Rate)**	**D(Broad Money)**
1	135.3376	0.039513	0.962413	98.99807	0	0	0
2	142.3412	0.121604	2.896084	90.73654	1.715478	0.006471	4.523823
3	149.4184	0.123829	2.916422	90.10458	1.814341	0.894359	4.146465
4	168.7043	0.216769	3.403364	89.64235	2.608897	0.873176	3.255439
5	176.3918	0.201298	3.946432	87.77274	2.531717	0.905053	4.64276
6	183.9626	0.208114	3.742131	87.96756	2.701717	1.085213	4.295264
7	194.6334	0.217103	4.151249	87.76272	2.79657	1.009427	4.062931
8	202.035	0.209205	4.388942	87.37472	2.827056	1.02207	4.178008
9	209.1546	0.195205	4.341916	87.42087	3.000292	1.035631	4.00609
10	217.3256	0.189322	4.573568	87.30615	3.041089	0.95952	3.930356
11	224.2036	0.179611	4.619474	87.27814	3.067343	0.954894	3.900542
12	230.9248	0.170948	4.656808	87.26591	3.15417	0.932525	3.819635

Variance Decomposition of D(REER)							
Period	**S.E.**	**D(Tradable Inflation)**	**D(IIP)**	**D(Net Trade Balance)**	**D(REER)**	**D(Interest Rate)**	**D(Broad Money)**
1	1.757681	2.044559	3.288735	7.3585	87.30821	0	0
2	1.955484	11.19685	6.387239	6.31474	73.81676	0.504565	1.779853
3	2.405334	19.32684	24.3696	5.314409	49.47838	0.334317	1.17645
4	2.644919	20.92001	25.00829	10.12384	42.12174	0.396358	1.429776
5	2.773941	22.21444	25.1619	9.66298	40.69776	0.360998	1.901922
6	2.959703	23.02057	26.89324	9.172295	38.80161	0.387582	1.724703
7	3.112868	23.78111	26.97237	9.890934	37.3073	0.375885	1.672397
8	3.271159	24.91097	28.09784	9.777048	35.07191	0.342682	1.799552
9	3.426015	25.6642	29.03738	9.754269	33.48139	0.325026	1.73773
10	3.557037	26.20234	29.25822	9.995321	32.46599	0.314447	1.763683
11	3.690089	26.68636	29.76081	9.965483	31.51238	0.296939	1.778031
12	3.82031	27.11889	30.17405	9.967897	30.70457	0.279426	1.75517
Variance Decomposition of D(Call Money Rate)							
Period	**S.E.**	**D(Tradable Inflation)**	**D(IIP)**	**D(Net Trade Balance)**	**D(REER)**	**D(Interest Rate)**	**D(Broad Money)**
1	1.403282	0.279766	1.226073	0.015263	0.025614	98.45328	0
2	1.421979	0.786314	1.599302	0.170143	0.384269	96.3722	0.687768
3	1.560603	0.664025	1.856182	0.265029	0.371446	96.01926	0.824061
4	1.735949	0.537911	1.529545	0.388293	0.32799	96.54329	0.672974
5	1.78406	0.53278	1.542209	0.367713	0.367765	96.11828	1.071255
6	1.900959	0.47777	1.448423	0.326125	0.3245	96.43801	0.985172
7	1.996272	0.446465	1.317456	0.383908	0.333557	96.57458	0.944036
8	2.063381	0.427346	1.3302	0.364021	0.319005	96.54285	1.016582
9	2.153782	0.403579	1.230239	0.339642	0.299741	96.74476	0.982043
10	2.230693	0.384554	1.157869	0.338083	0.299538	96.83512	0.984839
11	2.299814	0.369473	1.130269	0.318073	0.288526	96.89968	0.993975
12	2.376206	0.354615	1.067133	0.305502	0.280449	97.00832	0.983983
Variance Decomposition of D(Broad Money)							
Period	**S.E.**	**D(Tradable Inflation)**	**D(IIP)**	**D(Net Trade Balance)**	**D(REER)**	**D(Interest Rate)**	**D(Broad Money)**
1	518.8204	0.071695	0.001471	0.300172	0.079174	1.822553	97.72494
2	556.6022	0.068434	0.168456	2.879196	2.870438	2.150504	91.86297
3	627.788	0.844487	1.212241	4.216806	4.111355	2.124691	87.49042
4	683.6502	0.867414	1.222665	3.798022	4.224105	2.170083	87.71771
5	733.1539	0.75432	1.069702	4.490524	4.401558	2.476836	86.80706
6	780.5482	0.724627	1.108889	4.566367	4.318879	2.426473	86.85476
7	822.8343	0.725317	1.099574	4.523591	4.412875	2.415793	86.82285
8	867.1161	0.715474	1.112632	4.778086	4.565	2.549688	86.27912
9	906.5638	0.69823	1.11636	4.842901	4.641099	2.536375	86.16504
10	944.2874	0.683795	1.099947	4.868502	4.692664	2.557365	86.09773
11	981.5996	0.671282	1.095915	4.951043	4.719153	2.59923	85.96338
12	1016.784	0.66058	1.091496	4.991348	4.760971	2.598817	85.89679
Cholesky Ordering: D(Tradable Inflation) D(IIP) D(Net Trade Balance) D(REER) D(Call Money Rate) D(Broad Money)							

Source: Author's Calculation

The above table 5.3 presents the result of variance decomposition of tradable inflation, IIP, REER, net trade balance, call money rate and broad money. Initially, variation in tradable inflation is explained 100 percent by its own shock but by the end of twelfth month 91 percent of variation explained by its own shock and around 5 percent of variation is explained by REER and around 1 percent of variation explained by IIP. In case of IIP around 97 percent of variation explained by its own shock and 2 percent of variation explained tradable inflation.By the end of twelfth period around 93 percent variation explained by its own shock, 2 percent variation explained by REER and 1 percent variation explained by tradable inflation. While in case of REER, initially 87 percent of variation explained by its own shock,7 percent of variation explained by net trade balance, 3 percent variation explained by IIP and 2 percent of variation explained by tradable inflation. By the end of twelfth month around 30 percent of variation explained by its own shock and 9 percent of variation explained by net trade balance, 30 percent variation explained by IIP, 27 percent of variation explained by tradable inflation and around 1 percent of variation explained broad money. In case of Broad money initially around 97 percent of variation explained by its own shock. By the end of twelfth month 85 percent of variation explained by its own shock, 3 percent of variation explained by interest rate, 1 percent variation explained by IIP and around 4 percent of variation explained by REER and net trade balance. In case of net trade balance around 98 percent of variation explained by its own shock. By the end of twelfth month around 87 percent of variation explained by its own shock, 4 percent of variation explained by IIP and 3 percent of variation explained by both REER and broad money. In case of interest rate, 98 percent of variation explained by its own shock and 1 percent of variation explained by IIP. By the end of twelfth month 97 percent of variation explained by its own shock and around 1 percent of variation explained by IIP.

Non-Tradable Inflation and Its Impact on the Economy

Further, we examine the impact of non-tradable inflation on the macroeconomic variables of India. Whether following non-tradable inflation measure as a measure of inflation improves the macroeconomic performance of India or not? We have already tested the sationarity of the variables and found that all the variables are stationary at the

first difference. We also checked the possibility of presence of co-integration among variables by conducting Johanson Juselius test of co-integration and found that there are two co-integrating vector exists among variables and the result of co-integration presented in table A6 in appendix. As we found the presence of co-integrating relationship between variables, we proceed for VECM analysis and analyse the impulse response function and variance decomposition. We also checked the stability of the VEC model, by testing AR root graphs,which shows that VEC model stratifies the stability conditionand the result is given in figure A4 in appendix.

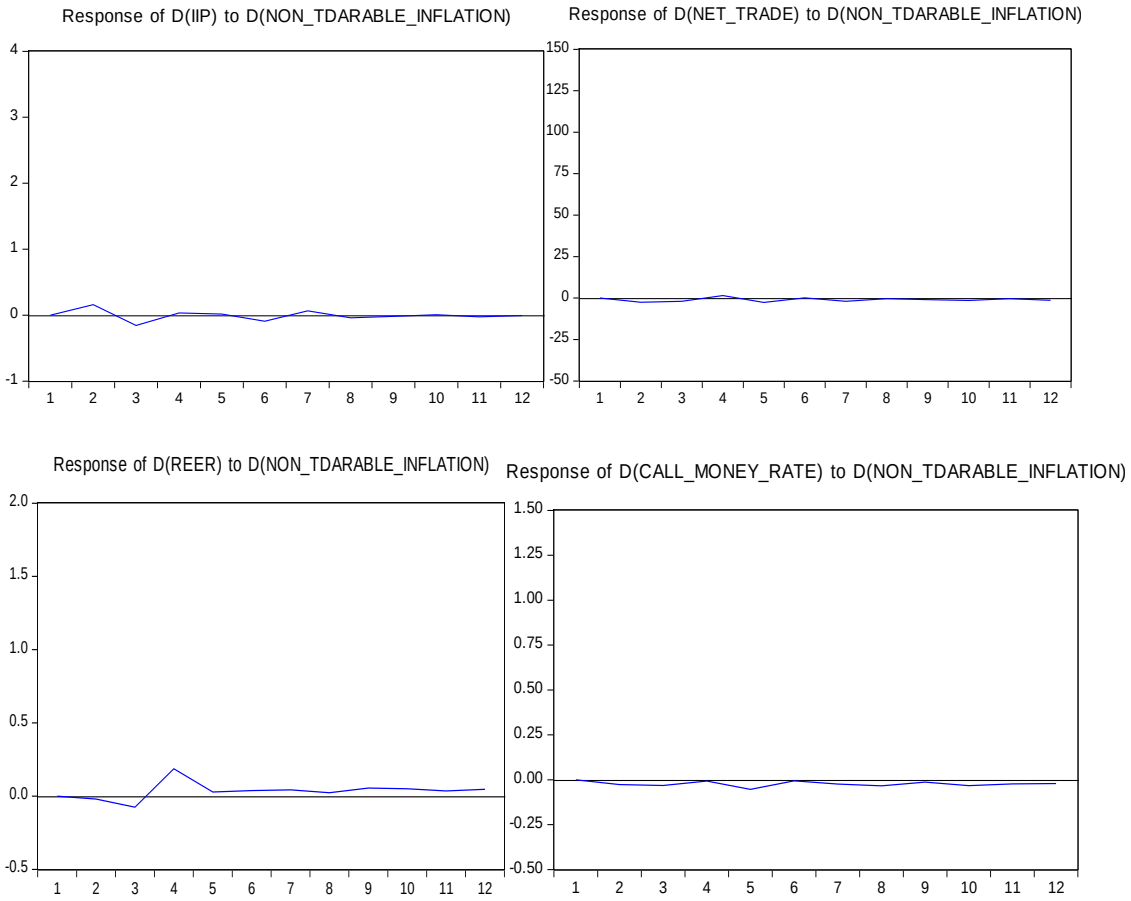


Figure 5.3: Impulse Response Function of Macroeconomic Variables to One Standard Deviation of Non-Tradable Inflation
Source: Author's Calculation

Figure 5.3 presents the impulse response function of various macroeconomic variables in response to the one standard deviation shock to the non-tradable inflation.

As we know, non-tradable inflation purely represents the domestic inflation it does not affect much net trade. It also does not affect much call money rate. While in case of IIP it flows a cyclical fluctuation: in the first period it rises, in the second period it starts to fall, from the third period again it rises and finally it dies out in the eighth period. In response to shock to the non-tradable inflation, REER starts to fall immediately up to the third period and after the third period there is a sharp rise up to the fourth period, after the fourth period it falls up to the fifth period and maintain that level of inflation.

Table 5.4
Result of Variance Decomposition

Variance Decomposition of D(Non Tradable Inflation)							
Period	**S.E.**	**D(Non Tradable Inflation)**	**D(IIP)**	**D(Net Trade Balance)**	**D(REER)**	**D(Interest Rate)**	**D(Broad Money)**
1	0.73929	100	0	0	0	0	0
2	0.794755	99.30974	0.260753	0.083245	0.098652	0.125245	0.12237
3	0.893302	99.1056	0.206604	0.103997	0.10837	0.222446	0.252984
4	0.992342	98.84371	0.489775	0.097898	0.14471	0.181739	0.242164
5	1.063452	98.96349	0.439017	0.101637	0.126115	0.158722	0.211018
6	1.13823	99.04182	0.403289	0.101669	0.119064	0.149931	0.184221
7	1.209016	99.08508	0.419739	0.090141	0.105994	0.135598	0.163443
8	1.272847	99.14308	0.396011	0.090499	0.098438	0.124104	0.147868
9	1.335442	99.17148	0.399256	0.085609	0.095406	0.113881	0.134369
10	1.394772	99.20623	0.39647	0.079997	0.089647	0.104402	0.123255
11	1.451304	99.24019	0.384382	0.078074	0.085587	0.097583	0.114181
12	1.506282	99.26195	0.384517	0.074914	0.081922	0.090694	0.105998
Variance Decomposition of D(IIP)							
Period	**S.E.**	**D(Non Tradable Inflation)**	**D(IIP)**	**D(Net Trade Balance)**	**D(REER)**	**D(Interest Rate)**	**D(Broad Money)**
1	3.078688	0.887541	99.11246	0	0	0	0
2	3.142257	1.004192	96.51148	0.330734	1.587999	0.13785	0.427748
3	3.419043	0.848432	96.75254	0.279353	1.34625	0.366065	0.40736
4	3.673298	0.799285	92.68139	0.404901	3.918105	1.445836	0.750482
5	3.741015	0.870378	92.44355	0.508906	3.888176	1.565311	0.723682
6	3.966384	0.775751	92.79286	0.463147	3.831382	1.420207	0.716651
7	4.083291	0.852966	92.33519	0.503456	4.099741	1.464994	0.743657
8	4.195825	0.83458	92.3219	0.539704	4.173851	1.414583	0.715377
9	4.344358	0.802572	92.19744	0.52871	4.325553	1.411495	0.734235
10	4.451718	0.813739	92.04056	0.572671	4.484291	1.353792	0.734949
11	4.572676	0.797525	92.09254	0.574811	4.531219	1.284162	0.719743
12	4.692168	0.787535	92.00927	0.581742	4.631074	1.25875	0.731629
Variance Decomposition of D(NET_TRADE_BALANCE)							
Period	**S.E.**	**D(Non Tradable Inflation)**	**D(IIP)**	**D(Net Trade Balance)**	**D(REER)**	**D(Interest Rate)**	**D(Broad Money)**

1	136.6211	2.53302	0.379549	97.08743	0	0	0
2	143.6839	2.296093	1.835733	89.78975	0.533796	0.07353	5.471103
3	151.771	2.237587	1.645994	89.54168	0.478922	1.096248	4.999569
4	171.3533	2.37395	1.750024	90.1263	0.834418	0.976591	3.938714
5	179.6931	2.196871	2.108483	88.29173	0.768064	1.038667	5.596189
6	187.8168	2.235831	1.93038	88.67387	0.755271	1.219152	5.185497
7	198.7075	2.13178	2.177124	88.82009	0.807103	1.097492	4.966414
8	206.6955	2.112018	2.212737	88.61584	0.770926	1.126612	5.161867
9	214.1252	2.092868	2.116028	88.84773	0.798901	1.153804	4.990666
10	222.6051	2.044668	2.238121	88.91933	0.798602	1.070714	4.928564
11	229.9336	2.041011	2.199046	88.97644	0.783118	1.07524	4.925142
12	236.9286	2.014067	2.180223	89.08938	0.795433	1.064469	4.85643
Variance Decomposition of D(REER)							
Period	**S.E.**	**D(Non Tradable Inflation)**	**D(IIP)**	**D(Net Trade Balance)**	**D(REER)**	**D(Interest Rate)**	**D(Broad Money)**
1	1.741838	0.004671	4.909094	4.827945	90.25829	0	0
2	1.867209	0.123037	12.70644	4.202652	81.315	0.031169	1.621699
3	2.297474	0.153045	40.69897	2.946566	53.8951	1.234538	1.071788
4	2.517659	1.035181	43.59312	6.471418	45.25104	2.457166	1.192074
5	2.619561	1.118234	45.46891	6.222296	42.98195	2.568463	1.640151
6	2.781976	1.152592	48.7343	5.825246	40.39476	2.352469	1.540631
7	2.907695	1.176016	49.72225	6.171395	38.75923	2.673912	1.497189
8	3.045686	1.202144	52.28474	5.994075	36.1648	2.729845	1.624398
9	3.180184	1.266976	54.39954	5.934379	34.12068	2.705706	1.572709
10	3.293864	1.320066	55.38093	6.054593	32.72148	2.917106	1.605821
11	3.410478	1.336327	56.69767	6.00446	31.42705	2.901039	1.63346
12	3.522272	1.369124	57.75853	5.967821	30.37229	2.911986	1.620247
Variance Decomposition of D(Interest Rate)							
Period	**S.E.**	**D(Non Tradable Inflation)**	**D(IIP)**	**D(Net Trade Balance)**	**D(REER)**	**D(Interest Rate)**	**D(Broad Money)**
1	1.390367	1.478392	0.725342	0.05825	0.369644	97.36837	0
2	1.409325	1.596388	1.83526	0.137705	0.367946	95.03082	1.03188
3	1.539479	1.40959	1.554997	0.322766	1.211546	94.30287	1.198235
4	1.706527	1.250478	1.698235	0.424664	1.59162	94.05556	0.979442
5	1.752291	1.19983	1.619067	0.418512	1.584446	93.68012	1.498025
6	1.863468	1.172356	1.441026	0.382002	1.761219	93.82434	1.419054
7	1.955684	1.076165	1.432076	0.436648	1.737215	93.92004	1.397853
8	2.01845	1.017977	1.344434	0.433724	1.84391	93.85225	1.507709
9	2.104858	0.976458	1.2966	0.399734	1.92825	93.90994	1.48902
10	2.178691	0.917055	1.235893	0.385043	1.948842	93.99693	1.516238
11	2.244009	0.882999	1.172703	0.366552	2.007307	94.02818	1.542258
12	2.317398	0.846102	1.134302	0.345965	2.035914	94.08877	1.548946
Variance Decomposition of D(Broad Money)							
Period	**S.E.**	**D(Non Tradable Inflation)**	**D(IIP)**	**D(Net Trade Balance)**	**D(REER)**	**D(Interest Rate)**	**D(Broad Money)**
1	529.2567	0.781153	0.018113	0.009448	0.465507	2.784364	95.94142

2	564.702	0.711007	0.087853	1.499802	1.573804	3.722555	92.40498
3	633.1447	0.670507	1.133785	2.175989	2.188665	4.189626	89.64143
4	693.0791	0.561774	1.06249	1.841032	2.151748	4.34909	90.03387
5	744.5825	0.58046	0.921552	2.381483	2.12728	4.613431	89.37579
6	791.8797	0.558835	0.9818	2.373747	2.006747	4.67856	89.40031
7	836.002	0.515855	0.936101	2.264416	2.001136	4.708961	89.57353
8	881.4945	0.505745	0.941105	2.400832	2.023775	4.91032	89.21822
9	921.4287	0.482179	0.93544	2.411947	2.019535	4.953455	89.19744
10	960.3661	0.463578	0.912444	2.389895	2.022064	4.998276	89.21374
11	998.7004	0.453019	0.90573	2.423672	2.003677	5.072439	89.14146
12	1034.579	0.440724	0.892266	2.429181	1.998786	5.102451	89.13659
Cholesky Ordering: D(Non-tradable Inflation) D(IIP) D(Net Trade Balance) D(REER) D(Call Money Rate) D(Broad Money)							

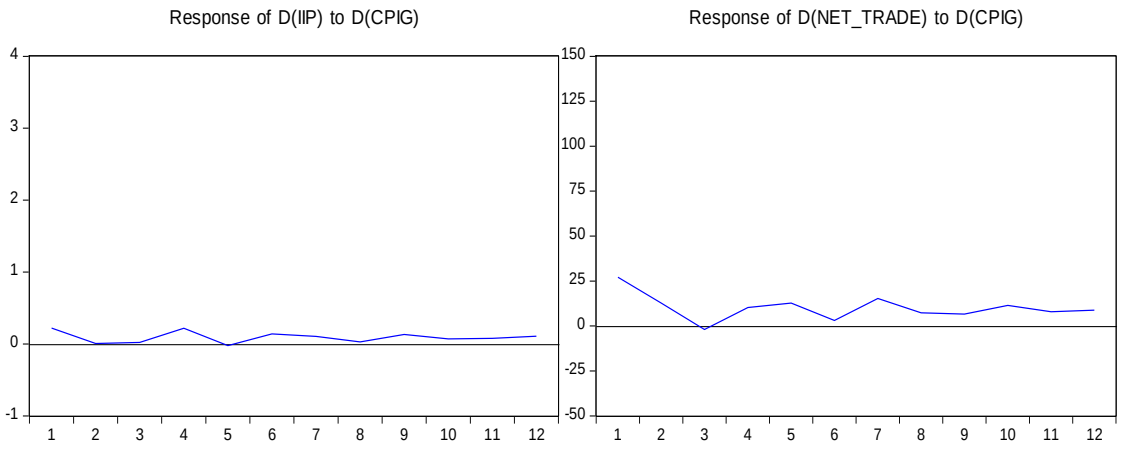
Source: Author's Calculation

The above table 5.4 presents the result of variance decomposition of non-tradable inflation, IIP, REER, net trade balance, call money rate and broad money. Initially, variation in non-tradable inflation is explained 100 percent by its own shock but by the end of twelfth month 99 percent of variation explained by its own shock. In case of IIP around 99 percent of variation explained by its own shock. By the end of twelfth period around 92 percent variation explained by its own shock, 4 percent variation explained by REER and 1 percent variation explained by interest rate. While in case of REER, initially 90 percent of variation explained by its own shock, 4 percent of variation explained by both net trade balance and IIP. By the end of twelfth month around 30 percent of variation explained by its own shock, 5 percent of variation explained by net trade balance, 57 percent variation explained by IIP, 2 percent of variation explained by interest rate, around 1 percent of variation explained broad money and net tradable inflation. In case of Broad money initially around 95 percent of variation explained by its own shock and around 2 percent of variation explained by interest rate. By the end of twelfth month 89 percent of variation explained by its own shock, 5 percent of variation explained by interest rate, 2 percent variation explained by net trade balance and around 1 percent of variation explained by REER. In case of net trade balance around 97 percent of variation explained by its own shock and 2 percent variation explained by net trade balance. By the end of twelfth month around 89 percent of variation explained by its own shock, 4 percent of variation explained by broad money and 2 percent of variation explained by both non-tradable inflation and IIP. In case of interest rate, 97 percent of variation explained by its own shock and 1 percent of variation explained by non-

tradable inflation. By the end of twelfth month 97 percent of variation explained by its own shock, around 2 percent of variation explained by REER and 1 percent of variation explained by broad money.

CPI with Gold and Its Impact on the Economy

We further examine the impact of CPI with gold inflation on the macroeconomic variables of India. Whether following CPI with gold inflation measure as a measure of inflation improves the macroeconomic performance of India or not? We have already tested the sationarity of the variables and found that all the variables are stationary at the first difference. We also checked the possibility of presence of co-integration among variables by conducting Johanson Juselius test of co-integration and found that there are two co-integrating vector exists among variables and the result of co-integration given in table A6 in appendix. As we found the presence of co-integrating relationship between variables, we proceed for VECM analysis and analyse the impulse response function and variance decomposition. We also checked the stability of the VEC model, by testing AR root graphs,which shows that VEC model stratifies the stability conditionand the result is given in figure A5 in appendix.



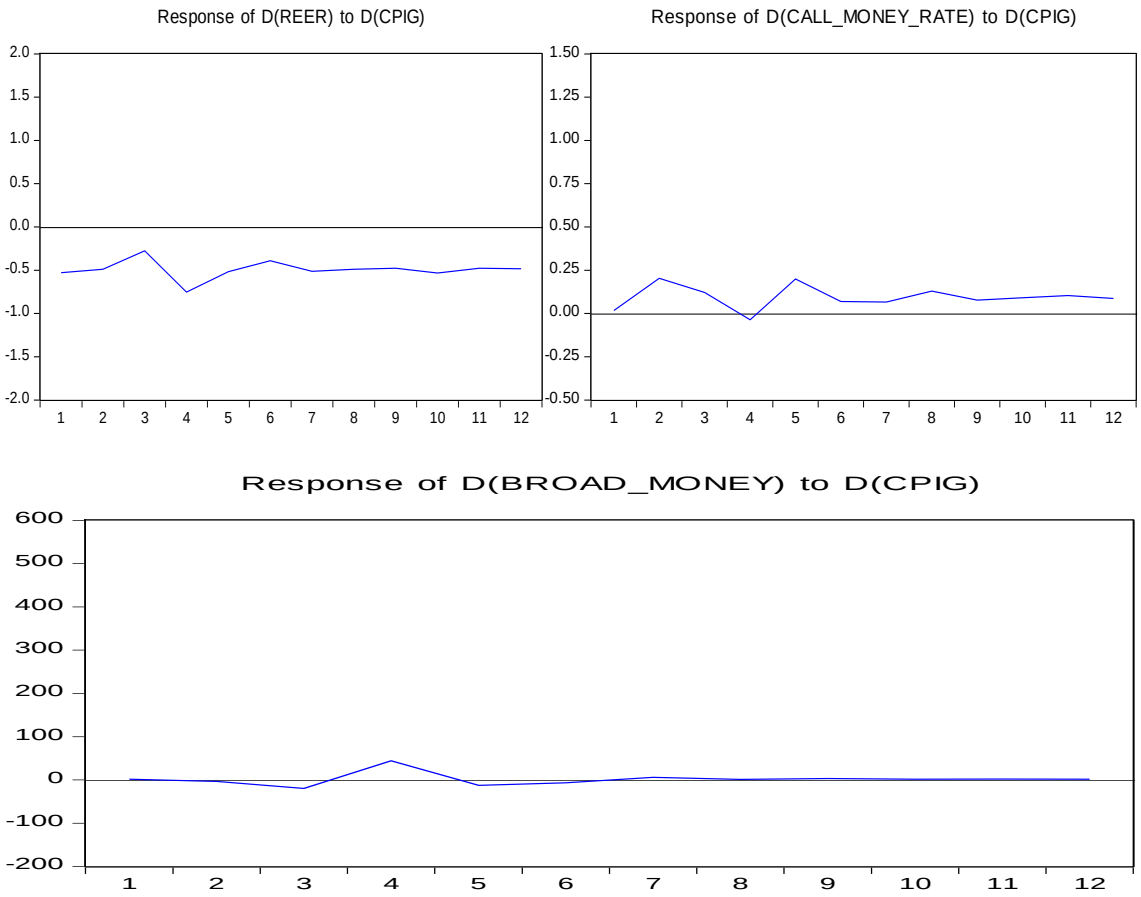


Figure 5.4: Impulse Response Function of Macroeconomic Variables to One Standard Deviation of CPI with Gold Inflation
Source: Author's Calculation

Figure 5.4 presents the impulse response function of various macroeconomic variables in response to the one standard deviation shock to CPI with gold inflation. Any shock to the CPI with gold is making the fluctuation in the economy; but it does not have a significant impact on broad money and it is affecting only in between the third to the fifth period. Shock to CPI gold is leading to cyclical fluctuations in IIP, net trade, REER and call money rate. Net trade and IIP in immediate response to shock to CPI with gold starts to fall. Then IIP become stable for one period and again start to rise in the third period and starts falling in the fourth period. While net trade start to rise immediately in the second period, after that it follows the cyclical pattern. Interest rate and REER also follows a cyclical manner; but in response to immediate effect, it rises and then follows the cyclical pattern.

Table 5.5
Result of Variance Decomposition

Variance Decomposition of D(CPIG)							
Period	**S.E.**	**D(CPIG)**	**D(IIP)**	**D(Net Trade Balance)**	**D(REER)**	**D(Interest Rate)**	**D(Broad Money)**
1	3.768136	100	0	0	0	0	0
2	4.086102	98.52764	0.074829	0.377408	0.457553	0.559106	0.003467
3	4.346408	97.8474	0.068679	0.405142	0.962352	0.532884	0.183539
4	4.880863	97.76758	0.12169	0.561308	0.951727	0.448952	0.148742
5	5.232306	97.30025	0.114866	0.839803	0.916666	0.654569	0.173848
6	5.549055	97.35945	0.121855	0.803591	0.951769	0.599015	0.16432
7	5.869564	97.52691	0.116396	0.729188	0.94234	0.537472	0.147691
8	6.170745	97.45079	0.105707	0.726156	0.978009	0.574595	0.164739
9	6.45391	97.49623	0.119117	0.682129	1.00781	0.539617	0.155102
10	6.719032	97.58281	0.110139	0.63184	1.014719	0.510749	0.149739
11	6.984801	97.60348	0.10611	0.612004	1.019997	0.507876	0.150537
12	7.236733	97.64735	0.106667	0.584116	1.027084	0.490138	0.144646
Variance Decomposition of D(IIP)							
Period	**S.E.**	**D(CPIG)**	**D(IIP)**	**D(Net Trade Balance)**	**D(REER)**	**D(Interest Rate)**	**D(Broad Money)**
1	3.176356	0.486692	99.51331	0	0	0	0
2	3.182135	0.485282	99.29505	0.122333	0.047218	0.019087	0.031033
3	3.642437	0.373605	98.455	0.167505	0.410732	0.465949	0.127204
4	3.922189	0.630124	97.84623	0.173868	0.46257	0.64903	0.238174
5	4.011077	0.605997	97.39891	0.244239	0.525286	0.956558	0.269011
6	4.327096	0.625086	97.63511	0.217772	0.458669	0.827096	0.236267
7	4.460671	0.642999	97.69191	0.214355	0.432293	0.78299	0.23545
8	4.630606	0.600839	97.62522	0.216051	0.448809	0.869149	0.239934
9	4.824216	0.627497	97.71793	0.199686	0.416268	0.802013	0.236607
10	4.957117	0.615344	97.77475	0.203696	0.400483	0.781579	0.224148
11	5.124365	0.59864	97.84747	0.194946	0.390043	0.758313	0.210585
12	5.273522	0.606098	97.91491	0.185059	0.371975	0.717552	0.204402
Variance Decomposition of D(Net Trade Balance)							
Period	**S.E.**	**D(CPIG)**	**D(IIP)**	**D(Net Trade Balance)**	**D(REER)**	**D(Interest Rate)**	**D(Broad Money)**
1	128.0214	4.490927	0.165668	95.3434	0	0	0
2	134.6417	4.961567	1.693691	86.201	4.423906	0.008977	2.71086
3	138.9748	4.677352	1.797447	84.03345	6.130774	0.736943	2.624031
4	154.5116	4.222396	2.637882	80.17319	9.84716	0.840655	2.278713
5	160.1666	4.566917	2.867977	78.17456	10.17382	0.979065	3.237663
6	165.5408	4.310114	2.702494	78.16442	10.73872	1.027975	3.056282
7	174.0429	4.668965	3.260874	77.26331	10.97561	0.978248	2.852992
8	179.2242	4.571537	3.353621	76.41381	11.80566	1.012015	2.843355
9	184.5479	4.440464	3.352618	75.94907	12.58369	0.990641	2.683515
10	190.6701	4.52353	3.635078	75.33516	12.98926	0.928333	2.588641
11	195.8518	4.452166	3.608848	75.11965	13.38866	0.924419	2.506256

12	200.9391	4.420242	3.679904	74.8017	13.7969	0.892807	2.408444
Variance Decomposition of D(REER)							
Period	**S.E.**	**D(CPIG)**	**D(IIP)**	**D(Net Trade Balance)**	**D(REER)**	**D(Interest Rate)**	**D(Broad Money)**
1	1.846803	8.156166	0.351159	8.962616	82.53006	0	0
2	2.052173	12.28555	0.398111	10.14843	73.66199	1.048844	2.45707
3	2.277655	11.44627	9.443183	14.88503	61.09394	0.978869	2.152707
4	2.630895	16.75621	7.966876	25.64309	46.19453	0.733886	2.705405
5	2.782365	18.41501	8.051516	25.74893	43.39497	0.691617	3.697954
6	2.927188	18.41541	8.781638	26.25671	42.26301	0.767432	3.515797
7	3.085809	19.33926	8.215133	27.28627	40.94458	0.69544	3.519322
8	3.236665	19.8552	8.728356	28.11526	38.83007	0.707374	3.763746
9	3.374791	20.2545	9.00293	29.10981	37.17269	0.713796	3.746266
10	3.51205	20.99924	8.882622	29.91712	35.64059	0.666519	3.893912
11	3.640254	21.2589	9.074581	30.40089	34.6488	0.671558	3.945273
12	3.760952	21.57178	9.082718	30.83551	33.88175	0.663592	3.964647
Variance Decomposition of D(Interest Rate)							
Period	**S.E.**	**D(CPIG)**	**D(IIP)**	**D(Net Trade Balance)**	**D(REER)**	**D(Interest Rate)**	**D(Broad Money)**
1	1.379425	0.015962	1.895812	0.219059	0.63354	97.23563	0
2	1.411323	2.096538	2.120967	0.863325	1.294369	93.15634	0.468464
3	1.551483	2.344908	2.788516	0.726032	1.115457	92.44666	0.578432
4	1.72237	1.946612	2.295262	0.952989	1.71799	92.54631	0.540833
5	1.783488	3.061766	2.198222	1.030363	1.724742	91.0306	0.954304
6	1.894405	2.846569	2.224198	0.933876	1.726789	91.41585	0.852719
7	1.982904	2.709289	2.039316	0.97295	1.83768	91.64344	0.797329
8	2.05815	2.910844	2.076104	1.015412	1.865255	91.27085	0.861537
9	2.142833	2.815154	1.977884	0.97752	1.899437	91.52359	0.806416
10	2.218131	2.796152	1.903675	0.998905	1.962776	91.5467	0.791789
11	2.290633	2.827997	1.888266	1.006097	1.973264	91.51132	0.793056
12	2.36321	2.791197	1.817445	0.993739	2.005683	91.6272	0.764731
Variance Decomposition of D(Broad Money)							
Period	**S.E.**	**D(CPIG)**	**D(IIP)**	**D(Net Trade Balance)**	**D(REER)**	**D(Interest Rate)**	**D(Broad Money)**
1	513.8359	0.001009	0.226362	1.610402	0.000194	0.875404	97.28663
2	553.2643	0.004481	0.280026	7.185015	1.935456	0.891343	89.70368
3	622.6648	0.101989	0.528107	10.00663	3.546255	0.857703	84.95932
4	682.3498	0.506736	0.43977	9.566832	4.72947	0.804307	83.95289
5	732.0666	0.469013	0.456292	10.76678	4.717755	1.031332	82.55882
6	779.2362	0.42142	0.407046	11.03168	4.590158	0.985788	82.56391
7	820.3751	0.385539	0.376303	10.87308	4.743255	0.935808	82.68601
8	865.954	0.346263	0.338331	11.59181	4.921899	1.032429	81.76927
9	905.487	0.31799	0.309562	11.85587	5.049801	1.003933	81.46284
10	942.6044	0.293712	0.28686	11.89069	5.168696	0.994681	81.36536
11	980.4968	0.271902	0.265269	12.11408	5.200379	1.023406	81.12496

12	1015.42	0.25375	0.249219	12.23773	5.245415	1.009676	81.00421
Cholesky Ordering: D(CPIG) D(IIP) D(Net Trade Balance) D(REER) D(Interest Rate) D(Broad Money)							

Source: Author's Calculation

The above table 5.5 presents the result of variance decomposition of CPI with Gold (CPIG), IIP, REER, net trade balance, call money rate and broad money. Initially, variation in CPIG is explained 100 percent by its own shock but by the end of twelfth month 97 percent of variation explained by its own shock and 1 percent variation explained by REER. In case of IIP around 99 percent of variation explained by its own shock. By the end of twelfth period around 97 percent variation explained by its own shock. While in case of REER, initially 82 percent of variation explained by its own shock, 8 percent of variation explained by both net trade balance and CPIG. By the end of twelfth month around 33 percent of variation explained by its own shock, 30 percent of variation explained by net trade balance, 9 percent variation explained by IIP, 3 percent of variation explained by broad money and around 21 percent of variation explained by CPIG. In case of Broad money, initially around 97 percent of variation explained by its own shock and around 1 percent of variation explained by net trade balance. By the end of twelfth month, 81 percent of variation explained by its own shock, 12 percent of variation explained by net trade balance, 1 percent variation explained by interest rate and around 5 percent of variation explained by REER. In case of net trade balance around 95 percent of variation explained by its own shock and 4 percent variation explained by CPIG. By the end of twelfth month, around 75 percent of variation explained by its own shock, 13 percent of variation explained by REER, 2 percent of variation explained by broad money, 3 percent of variation explained by IIP and 4 percent of variation explained CPIG. In case of interest rate, 97 percent of variation explained by its own shock and 1 percent of variation explained by IIP. By the end of twelfth, month 91 percent of variation explained by its own shock, around 1 percent of variation explained by IIP and 2 percent of variation explained by CPIG.

5.6. Conclusion

Our objective of this chapter is to find out, if central bank focuses on core inflation rather than headline inflation for conducting monetary policy, then it improves the macroeconomic performance of the economy or not. Earlier literatures have both views: that, targeting inflation by following core inflation leads to improve the macroeconomic performance and it also negatively affects the macroeconomic variables. We aim to find the impact of four different measures of core inflation on the macroeconomic performance of India. Except non-tradable inflation, all other three measures of inflation highly affect the REER. In case of net trade also, only CPI with gold is highly affecting the net trade. In response to the shock to all the measure of core inflation, IIP reacts in a cyclical manner. Call money rate is also highly responsive to the shock of trim core inflation and CPI with gold.

Chapter 6

Conclusion and Major Findings

The study examines the different measures of core inflation for India. Other than examining the existing measures of core inflation, we also try to find out how external factors and asset prices are affecting the inflation of Indian economy. After finding the different measures of core inflation for India, the ultimate motive is to find the performance of macroeconomic factors of following core inflation instead of headline inflation for conducting monetary policy. The importance of core inflation is realised after many countries adopted inflation targeting framework, with single objective of monetary policy to maintain a stable and low level of inflation. Australia, Finland, Canada, New Zealand, Spain, Sweden, and the United Kingdom were the first to shift their focus to inflation targeting. These seven small and medium countries break the tradition of exchange rate and multiple objectives of monetary policy framework and adopt one single objective of inflation targeting. Failure of other monetary policy regimes leads to adopt of this new monetary framework of inflation targeting. The monetary targeting framework fails in mid 1980s because of instable demand for money function and thealso collapse of the fixed exchange rate regime in the early 1990s. These seven countries have a very poor record of fighting with high level of inflation for past 30 years before adopting inflation targeting framework. But after adopting inflation targeting these countries have the record of both low inflation and monetary policy credibility.

A high level of inflation and its measures are always a serious problem for India since independence. While the whole world was following Consumer Price Index (CPI) as its measure of inflation, India was looking to Wholesale Price Index(WPI) as its measure of inflation. CPI is true indicator about the people's cost of living. India has many forms CPI index for different sections of people. It has different CPI index for rural population, index for urban population, different index for industrial worker,

agricultural labourer, and manual labourer. In this case considering CPI as the true index of inflation for India is too difficult. Finally, in 2010 central bank of India come up with a solution with new CPI index i.e. combined CPI, which includes CPI for rural area and CPI for urban area. Now India follows combine CPI as its general measure of headline inflation.

As we have already discussed for inflation in India is a serious chronic problem because of its dependence on monsoon in agriculture sector, poor road and infrastructure facilities to transport food items to the market and lack of proper storing facilities and energy import. The government has also historically, heavily borrowed to finance its spending and leading to a high level of inflation because of high fiscal deficit. These are the main reasons of high inflation in India. The annual CPI between 1960 and 2016 has averaged at 7.6% in 16 of those years, CPI has been in double digits and above 6% in 35 of 56 years. Even in the post 1991 reform era, CPI has averaged above 6% for 17 of 25 years. After shifting of combined CPI as its measure of headline inflation, it shifted to inflation targeting monetary policy framework. But, a developing country, India is ready to adopt inflation targeting approach. Under inflation targeting approach India has to focus on a single objective of maintain low inflation. To do this, it will focus on core inflation by ignoring supply side problem of inflation; but for India, supply side problem is a serious problem because of its poor infrastructure and traditional practice of farming. Because of the above reasons, India adopted a flexible inflation targeting approach. That is, it adopted inflation targeting approach for short period of time: from 5th August 2016 to March 31st 2021, and also the level of inflation to be maintainedflexibly. These is good for making central bank of India more accountable, transparent and improve the credibility of monetary policy.

Targeting inflation leads to focus on core inflation,Exclusion measure of core inflation is quite suitable to developed economy. But, it is not appropriate for a developing economy like India, where different price index is there to represent different sections of the population. WPI is generally used as main index to represent Indian inflation, but it has many drawbacks, i.e., it mainly represents industrial section, it does

not include service or non-tradable goods. Service sector and non-tradable goods also contribute to domestic inflation. Other than WPI, CPI is also another measure to represent the inflation; but it has two different index to represent urban and rural population of India separately. Finally, one consolidates CPI, which include both urban and rural population was constructed to represent India's inflation. In this context, focusing to particular price index as headline inflation and conducting monetary policy is difficult. While, conducting monetary policy it has to exclude short term and temporary fluctuations and find out the factors that contribute to Indian inflation in the long term. The analysis of the study focuses on the following objectives:

(1) To evaluate the existing measures of core inflation, such as exclusion method, limited influence estimator and structural vector auto regression method.
(2) To identify the domestic and imported core inflation of India.
(3) To examine the role of asset price in inflation in India.
(4) To examine the impact of core inflation on macroeconomic variables in India.

To analyse the studyempirically, we use some simple statistical tools and some econometric techniques. All the measures of core inflation are broadly divided into two categories, such as (a) statistical approach and (b) model based approach. The first objective of the study is to analyse the existing measures of core inflation suitable for India and the dynamic relationship between headline and core inflation. First,to analyse the statistical approach, we use the simple statistical tools like mean, standard deviation, covariance etc., and for model based approach we use the econometrics technique like Structural Vector Auto Regression (SVAR). SVAR was developed by Sims (1986) and Bernanke (1986). Though standard VAR was developed by Sims in 1980, it was criticised on the ground that it does not use any economic theory and it only helps in recovering the structural innovations from residuals by using Cholesky decomposition. To overcome from these problems Structural VAR was introduced. The major difference between standard VAR and Structural VAR is the use of economic theory. Structural VAR can be identified from reduced form of VAR model. It is helpful to separate out the economically unrelated influences in price index and also useful for forecasting purpose. After getting all the series of core inflation, we try to find out the existing dynamic

relation headline inflation and core inflation. We use Vector Error Correction (VECM) Model to identify this dynamic relation.

Our second objective is to find out the domestic and imported core inflation for India. Volatility in food prices are not the only reason, which creates short run or temporary fluctuations in the price index. Sometimes price of various commodities directly or indirectly get affected by changes in the world economy. This objective aims to find out the commodities that attracts inflation from the world economy. To analyse this, first we separated goods of price index into two categories i.e. tradable and non-tradable goods. Tradable goods are mostly associated with world economy and fluctuations in the world economy leads to affect the domestic economy through theses goods and non-tradable goods purely represent the fluctuations in the domestic economy. In the first objective the study use WPI to represent the inflation but WPI does not include non-tradable goods or service sectors in the index. For this reason, we use CPI instead of WPI to represent the inflation of the Indian economy. First we use factor analysis to categorise CPI index into two different sectors i.e. tradable and non-tradable goods, then we try to find out how fluctuations in the world economy transmitted to domestic economy through tradable goods by using Vector Auto-regression (VAR)model.

The third objective of the study is to find out the role of asset in Indian inflation. Our main motive of the study is to identify all the possible sources that contribute to Indian inflation. According to Alchain and Klein (1972), instead of looking to only current consumption basket for measuring inflation, we must focus on the current cost of expected lifetime consumption, as people lives in two periods. So, we also need to consider the future expectations of individuals. We are talking about considering individuals' investment in future or their behaviour towards future expectations of prices, and we must consider asset prices as indicator of these things, because asset prices can better represent the future movement of prices. Further, we can identify aspiring credit bubbles and take necessary monetary policy actions according to that. To identify the role of asset price in Indian inflation, first we added asset price in to the commodity

basket by assigning weightage to it. To assign weightage to the asset prices in commodity baskets we use Neo-Edgeworthian Index. Finally, after assigning weights we use Kalman filter to estimate the forecasted inflation from both headline series of inflation and also from the inflation series including asset prices.

Final or last objective of this study is to find out whether targeting core inflation is really improving the macroeconomic performance of India or not. The ultimate objective of every country is to achieve economic growth and a stable economy. After identifying all the possible factors those contributing to Indian inflation, the study aims to find whether adopting inflation targeting framework improves macroeconomic performance of the country or not. It is believed that, price stability is the pre-condition for sustained economic development from every aspect. In this objective, we are examining how all the measures of core inflation, we get from above mentioned three objectives, contribute to macroeconomic performance of the economy. To empirically analyse this, we use Vector Error Correction Model (VECM). We have also applied impulse response function to know how macroeconomic variables response to any changes in core inflation.

6.1. Major Findings

It is always questionable whether monetary policy focuses on core inflation or headline inflation. If it focuses on core inflation, it can avoid the problem of reacting to temporary fluctuations in the economy, which can permanently affect the economy; but the main goal of monetary policy is to control overall inflation. Our first objective aims to analyse the existing measure of core inflation and find the best measure of core inflation for India. In term of proper economic interpretation, model based approach is more appropriate than statistical approach. But, it is difficult to find out the proper restriction to identify Structural VAR and also it is difficult to communicate with public. In structural VAR we estimate core inflation according to its proper definition, while in case of statistical approach there is no proper logic behind excluding commodities from the index; but, it is easy to calculate, to communicate with public and maintain

transparency. So, we can suggest SVAR is a good measure to estimate core inflation though practically using it is difficult. But, if we will see practical applicability of the measures, then trimmed mean measure is better one. The study also finds that, trimmed mean measure is performing better than other two measure of core inflation. The study compares the performance of core inflation estimated from both the WPI and combined CPI; but the result shows that trimmed mean measure of core inflation estimated from combined CPI outperform than trimmed mean measure of core inflation estimated from WPI inflation.

While analysing the dynamic relationship between headline and core inflation, our result supports the findings of the previous studies that the speed and direction of adjustment between headline and core inflation depends on the different monetary regime. Any unexpected changes in the monetary policy affect consumer behaviour and also the price level before consumers starts considering rational expectation. In case of India, we see that trimmed mean measure is giving better result than non-food manufacturing product measure and also holding the definition of core inflation. Even Gamber, Smith and Eftimoiu also got the same result. But, as per the definition of core inflation, the headline inflation should adjust with core inflation; trimmed mean measure of core inflation estimated from combined CPI performs well and maximum adjustment is done by headline inflation than core inflation.

Chapter 3 aims to find how external shocks affecting the tradable and non-tradable inflation of India. To represent the external shocks, we have taken REER and oil price; because these two parameters are main channel of pass through of external shocks. Rise in oil price leads to an inflationary shock in the economy through two different channels. In the first round, it directly affects the price of energy products and indirectly affects the energy related cost of production of other goods and services. In the second round, increase in the cost of living leads to a demand for increase in wage among worker to maintain their real income. The study also finds the same result. External shocks have an immediate effect on tradable inflation as it directly associates with external economy, while it takes time to affect the non-tradable inflation. Because, it

affects the non-tradable sectors in the second round effect of the external shocks. Core inflation is estimated by excluding volatile goods from the consumption basket, but this volatility of the commodities may be not due to its nature of the commodity, but may be because of external shocks. Excluding these commodities does not fully extract the temporary fluctuations; there may be an existence of second round effect of external shocks in the core inflation.

Chapter 4finds out the role of asset in Indian inflation. As we already know people live in two periods, and their consumption habits depends on expectations. Therefore, we must consider this expectations and investment for the future, while estimating the level of inflation. Our monetary policy also operates with lag, considering people's expectation will help in an easy conduct of monetary policy, maintaining transparency and credibility. Therefore, our study aims to considering asset price (gold and equity) as a commodity of consumption basket and then estimated inflation. We also check the predictability of these inflation series. And the study finds that considering gold as commodity of consumption basket helps in predicting better level of inflation. But, here the problem is that, asset prices are highly fluctuating; they are more volatile than the items in normal consumption baskets of individuals. So, we cannot react to all the movements of asset prices. If any movements in asset prices signalling any inflationary or deflationary situation then, then only monetary policy must react to asset price movements. That means we have to find out the misalignments of asset prices.

Chapter 5 examines if central bank focuses on core inflation rather than headline inflation for conducting monetary policy, then it improves the macroeconomic performance of the economy or not. Earlier literatures have both views that targeting inflation by following core inflation leads to improve the macroeconomic performance and it also negatively affects the macroeconomic variables. We aim to find the impact of four different measures of core inflation on the macroeconomic performance of India. Except non-tradable inflation, all other three measures of inflation highly affect the REER. In case of net trade also, only CPI with gold is highly affecting the net trade. In response to the shock to all the measure of core inflation IIP reacts in a cyclical manner.

Interest rate is also highly responsive to the shock of trim core inflation and CPI with gold.

6.2. Policy Implications

For estimating core inflation, it is not justifiable to exclude food and fuel items from the price index. Every time all the food items are not volatile. Blindly excluding these items to get core inflation is not justified. It is here worth a mention that recent demand shock to oil prices and persistency in commodity prices such as gold and equity in an emerging economy like India suggest that monetary authority should consider different useful core inflation indicators in analysing the underlying inflation development and assessing outlook for inflation in the conduct of monetary policy. This study attempted to find out an alternative measure of core inflation which would be suitable for Indian economy. Other than finding an alternative measure of core inflation, the study also focuses on what the other factors are contributing to India's inflation role of asset price and external shocks in India's inflation. Based on VECM analysis, the results suggested that the domestic interest rate channel was stronger for core inflation; while money supply shock was stronger for CPI compared to the case of core one. Given that RBI generally operates its monetary policy management through interest rate channel under current policy framework, core inflation measures are thus seen to be more appropriate measures. A shock from world economy and fluctuations in asset price also affects the headline inflation. Hence, we need to find out volatility of these factors which has long term or short term impact on headline inflation. Short run impact form these fluctuations can be excluded while measuring core inflation. It is ensuring that the monetary policy of India needs to focus on core inflation. Other than the above problems, one of the major reasons to focus on core inflation is that, RBI as an authority to control monetary policy does not adopt full-fledged inflation targeting. Other than targeting inflation, it also focuses on the growth rate. It has to manage the trade-off between growth rate and inflation rate. The ultimate and important motive of an economy is to achieve economic growth.

In structural VAR we estimate core inflation according to its proper definition while in case of statistical approach there is no proper logic behind excluding commodities from the index but it is easy to calculate, to communicate with public and maintain transparency. Therefore, we can suggest SVAR is a good measure to estimate core inflation but practically using it is difficult. But if we will see practical applicability of the measures then trimmed mean measure is the better one. Rise in oil price leads to an inflationary shock in the economy through two different channels. In first round, it directly affects the price of energy products and indirectly affects the energy related cost of production of other goods and services. In second round, increase in cost of living leads to a demand for increase in wage among worker to maintain their real income. The study also finds the same result. External shocks have an immediate effect on tradable inflation as it directly associates with external economy, while it takes time to affect the non-tradable inflation as; it affects the non-tradable sectors in the second round effect of the external shocks. The Reserve Bank at that time chose not to tighten monetary policy in the expectation that the price would reverse itself later in the year when agricultural supplies improve. Notwithstanding this, given empirical disadvantages associated with conventional core measures, we suggest that the RBI should consider other useful core measures to generate overall outlook on dynamics of inflation development which can be the fed into the forward looking monetary policy framework.

6.3. Contribution to the Existing Literature

One of the major contributions of this study is the application of the econometric techniques to analyse the different existing measures of core inflation. There is very limited research done on the empirical analysis of the evaluation of measures of core inflation and its impact on macroeconomic performance of India. All the other studies mostly concern developed countries, but very few studies have been done for developing countries like India. Most of the earlier studies on measures of core inflation have considered WPI data set, mismatch in time period, homogenous economies and political situation. In reality, it is very difficult to find more studies on developing economies which are in verge of introducing inflation targeting framework.

6.4.Limitation of the Study

The present study has attempted to use up to date and appropriate data and methodology for the empirical analysis. However, the study has its limitations. The empirical findings of this study are restricted to the period of the study i.e. from January 2000 to April 2016. Certain variables such as housing price, gross capital flows and current account deficit in BoP situation have been dropped due to mismatched and unavailability of reliable data. Some macroeconomic variables such as domestic savings, foreign exchange reserve, and government expenditure on consumption had to be dropped because of non-relevance to our study as well as to avoid multicollinearity problem existing among independent variables. The study also backcasted the CPI data from 2010 to 2000, however, a real time data may give a better result and may explain the real inflationary scenario in India.

6.5.Scope for Further Research

The result of this study on the whole is interesting and may throw more light on current debates relating to combat of inflation situation in India and implementation of fixed and flexible Inflation Targeting (FIT). Some issues have been covered in this area and some needs to be addressed. Though the findings of the study are not providing any generalized outcomes, still the results can be referred by the researchers to avail a brief idea regarding the measures of core inflation in India. The present study can hopefully provoke further empirical research by taking into considerationthe study period from 5th of August 2016 to 31st of March, 2021 of inflation targeting approach adopted by Reserve Bank of India (RBI). However, this study is limited to the period from January, 2000 to April, 2016 with base year of 2004-05. It is hoped that econometrics tools and empirical models will motivate researchers for further study which can be covered from the period 5th August, 2016 to 31st, March 2021 in future. The study also hypothetically examines the impact of core inflation on macroeconomic performance of India. However, a real time study can be done after the period of 31st of March 2021 to know how exactly inflation targeting framework really helps to maintain the price stability and improves the macroeconomic performance of India. Also, a cross-country analysis can

be done among inflation targeting countries to check the overall performance of core inflation.

Appendix

Chapter 3

Table A1
Optimum Lag Order Selection Criterion

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1578.29	NA	262.7893	16.92286	16.99198*	16.95087*
1	-1557.55	40.36881	249.8147*	16.87218*	17.21775	17.0122
2	-1546.37	21.28945	263.0872	16.9237	17.54573	17.17574
3	-1536.56	18.24099	281.2872	16.98999	17.88848	17.35405
4	-1529.66	12.54476	310.3875	17.08732	18.26226	17.56341
5	-1518.94	19.04906	328.9754	17.14369	18.59509	17.7318
6	-1503.12	27.40159	330.4965	17.14566	18.87353	17.84579
7	-1485.37	30.00304*	325.5373	17.12689	19.13122	17.93905
8	-1469.91	25.45877	329.0227	17.1327	19.41348	18.05687

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Source: Author's Calculation

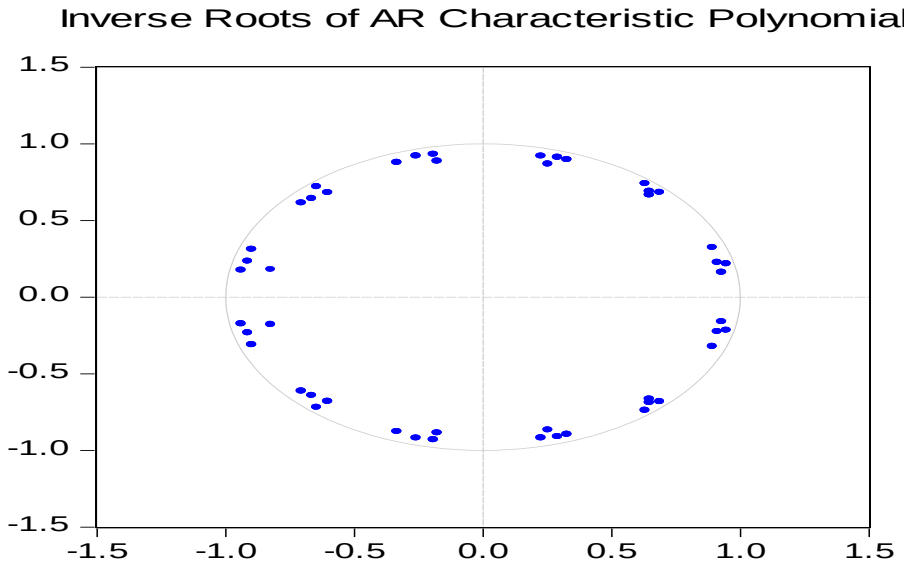


Figure A1: Stability Test of VAR Model
Note: No root lies outside the unit circle. VAR satisfies the stability condition.
Source: Author's Calculation

Chapter 5

Table A2
Result of Johansen Juselius Co-integration Test

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.353921	152.106	95.75366	0
At most 1	0.158834	69.10772	69.81889	0.0569
At most 2	0.085505	36.24408	47.85613	0.3842
At most 3	0.057244	19.26125	29.79707	0.4743
At most 4	0.041446	8.061202	15.49471	0.4589
At most 5	9.75E-05	0.01852	3.841466	0.8916

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Source: Author's Calculation

Table A3
Optimum Lag Order Selection Criterion

Lag	LogL	LR	FPE	AIC	SC	HQ
1	-3782.17	NA	2.73E+10	41.05558	41.67992*	41.30858*
2	-3728.43	100.5476	2.25e+10*	40.86482*	42.11349	41.37083
3	-3695.58	59.34182	2.34E+10	40.89869	42.7717	41.6577
4	-3658.2	65.11593	2.31E+10	40.88383	43.38119	41.89586
5	-3620.62	63.02499	2.30E+10	40.86692	43.98861	42.13195
6	-3584.64	58.04161	2.32E+10	40.86708	44.61311	42.38511
7	-3551.1	51.93609*	2.43E+10	40.89351	45.26387	42.66455
8	-3518.28	48.70086	2.58E+10	40.9277	45.9224	42.95174

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Source: Author's Calculation

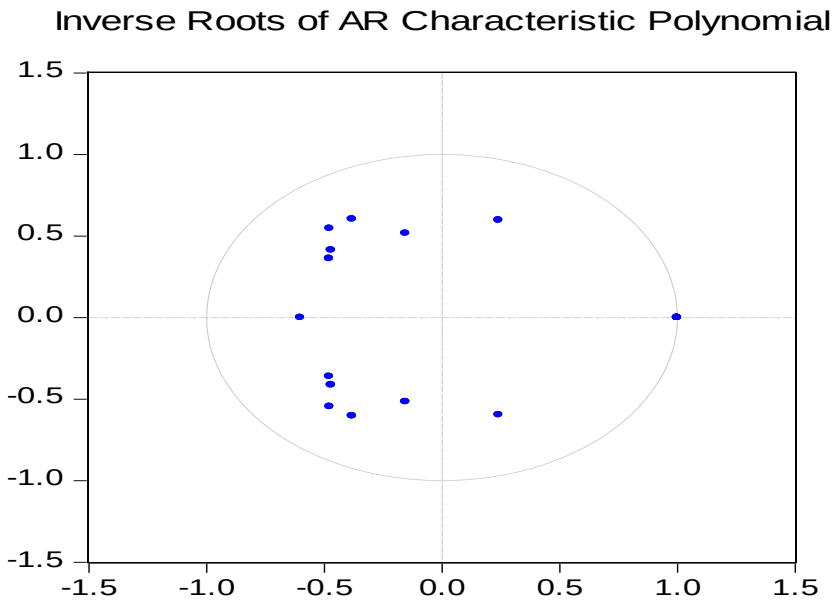


Figure A2: Stability Test of VEC Model

Note: VEC specification imposes 5 unit root(s).

Source: Author's Calculation

Table A4

Result of Johansen Juselius Co-integration Test

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.277904	149.9714	95.75366	0
At most 1 *	0.202544	87.45676	69.81889	0.001
At most 2	0.106336	44.0016	47.85613	0.1099
At most 3	0.065815	22.41589	29.79707	0.276
At most 4	0.047308	9.344373	15.49471	0.3345
At most 5	0.000205	0.03934	3.841466	0.8427

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Source: Author's Calculation

Table A5
Optimum Lag Order Selection Criterion

Lag	LogL	LR	FPE	AIC	SC	HQ
1	-3916.16	NA	1.15E+11	42.49637	43.12070*	42.74937*
2	-3861.11	103.0038	9.39E+10	42.29149	43.54016	42.7975
3	-3830.73	54.87289	1.00E+11	42.35196	44.22497	43.11098
4	-3794.48	63.1583	1.00E+11	42.34919	44.84654	43.36121
5	-3756.25	64.11725	9.87E+10	42.32528	45.44697	43.59031
6	-3710.89	73.16715*	9.04e+10*	42.22460*	45.97062	43.74263
7	-3678.47	50.19967	9.56E+10	42.26308	46.63345	44.03412
8	-3654.08	36.18721	1.11E+11	42.38795	47.38266	44.412

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Source: Author's Calculation

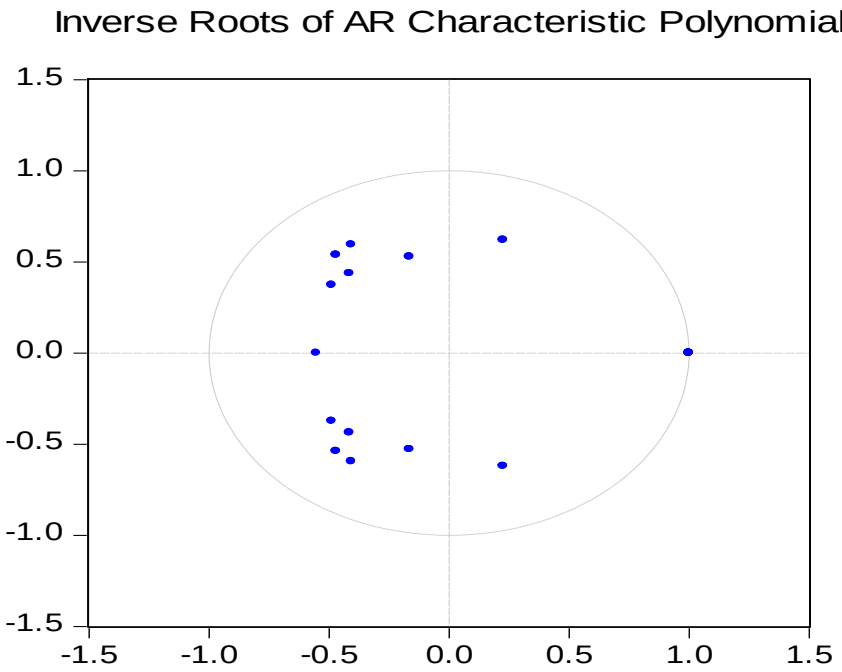


Figure A3: Stability Test of VEC Model
Note: VEC specification imposes 5 unit root(s).
Source: Author's Calculation

Table A6
Result of Johansen Juselius Co-integration Test

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.240556	126.9642	95.75366	0.0001
At most 1 *	0.156563	74.13172	69.81889	0.0217
At most 2	0.095366	41.43981	47.85613	0.175
At most 3	0.059077	22.1967	29.79707	0.2877
At most 4	0.047855	10.50515	15.49471	0.2439
At most 5	0.00566	1.08981	3.841466	0.2965

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Source: Author's Calculation

Table A7
Optimum Lag Order Selection Criterion

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-3880.13	NA	5.66E+10	41.78636	41.89041*	41.82852
1	-3820.26	115.2429	4.38E+10	41.52964	42.25803	41.82481*
2	-3781.12	72.79422	4.24e+10*	41.49596	42.84869	42.04414
3	-3750.49	55.01348	4.50E+10	41.55363	43.5307	42.35482
4	-3715.56	60.47317	4.58E+10	41.56512	44.16653	42.61931
5	-3683.41	53.57866	4.82E+10	41.60655	44.8323	42.91374
6	-3635.58	76.62727*	4.30E+10	41.47937*	45.32945	43.03957
7	-3602.74	50.49438	4.53E+10	41.51336	45.98778	43.32656
8	-3575.35	40.35975	5.10E+10	41.60586	46.70462	43.67207

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Source: Author's Calculation

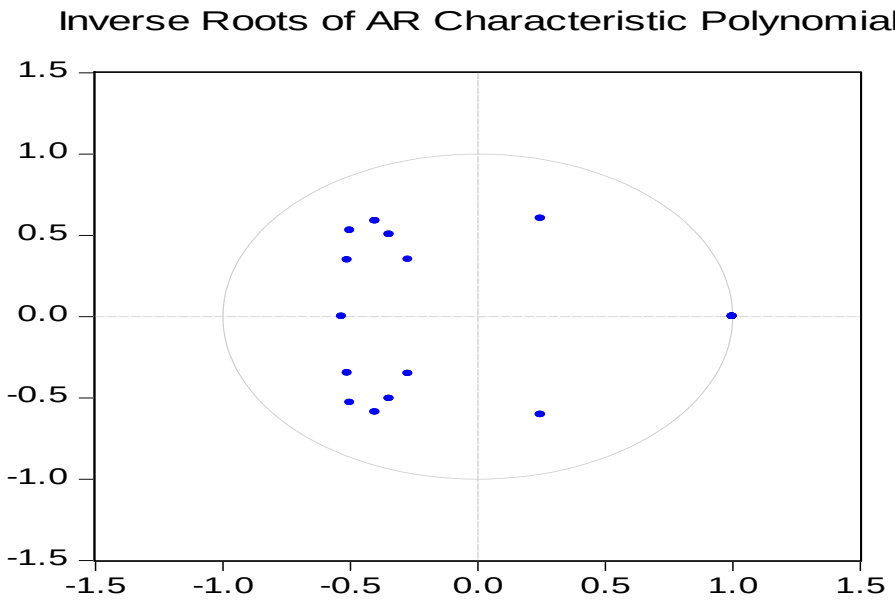


Figure A4: Stability Test of VEC Model
Note: VEC specification imposes 5 unit root(s).
Source: Author's Calculation

Table A8
Result of Johansen Juselius Co-integration Test

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.235394	141.9592	95.75366	0
At most 1 *	0.152662	90.42737	69.81889	0.0005
At most 2 *	0.145738	58.62149	47.85613	0.0036
At most 3	0.065578	28.37812	29.79707	0.0722
At most 4	0.045763	15.35542	15.49471	0.0525
At most 5 *	0.032591	6.361619	3.841466	0.0117

Trace test indicates 3 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Source: Author's Calculation

Table A9
Optimum Lag Order Selection Criterion

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-5434.03	NA	7.47E+17	58.18215	58.28583	58.22416
1	-4114.77	2539.752	8.18E+11	44.45745	45.18315*	44.75150*
2	-4071.38	80.7485	7.57e+11*	44.3784	45.72614	44.9245
3	-4048.76	40.64481	8.76E+11	44.52149	46.49126	45.31964
4	-4016.55	55.80825	9.17E+11	44.56203	47.15382	45.61222
5	-3972.69	73.17792	8.51E+11	44.47796	47.69179	45.78021
6	-3933.4	63.03829	8.32E+11	44.44273	48.2786	45.99703
7	-3900.21	51.1129	8.74E+11	44.47281	48.9307	46.27915
8	-3850.59	73.23579*	7.74E+11	44.32714*	49.40707	46.38553

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Source: Author's Calculation

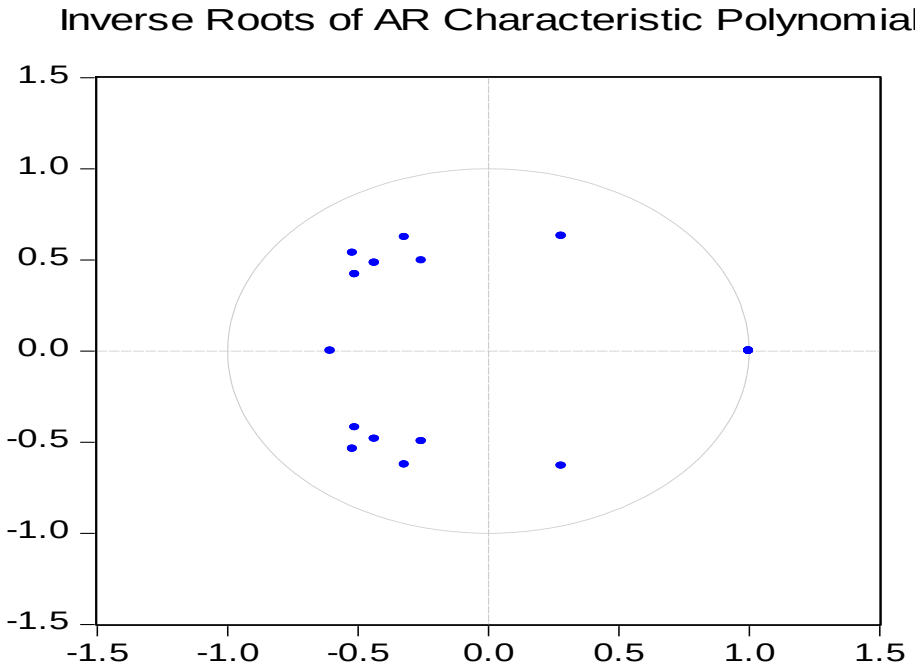


Figure A5: Stability Test of VEC Model
Note: VEC specification imposes 5 unit root(s).
Source: Author's Calculation

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Dissemination

Publications

- Samantaraya, A., Sahoo, A.k., Mallick, A. and Bhuyna, B. (2014 November 15). "Has Odisha Become Less Poor in the Last Decade?" *Economic & Political Weekly*, Vol. XLIX, No. 46, 62-67.
- Mallick, A., and Sethi, N. (2014). "Comparing the measures of core inflation in India: trimmed mean and structural vector auto-regression approach"*Int. J. Monetary Economics and Finance*, Vol. 7, No. 4, 288-301.
- Mallick, A., and Sethi, N. (2016). "Interaction between Monetary and Fiscal Policy: Empirical Evidence from India" *PRAGATI: Journal of Indian Economy*, Vol. 3, No.2, 1-15.
- Nayak, S., Sethi, N., Bujhabal, P., and Mallick, A. "Determinants and Pattern of Saving Behavior in Rural Household of Western Odisha: A Micro Level Analysis" Journal of Economic Policy & Research (Accepted for Sept, 2016-March, 2017 Issue)
- Mallick, A., Sethi, N., and Mohanty, M., "Dynamic Relationship between Headline and Core inflation in India: An Empirical Investigation" Journal of Financial Economic Policy (*Emerald, Under review*)
- Mallick, A., and Sethi, N., "Domestic and Imported Inflation in India" Macroeconomics and Finance in Emerging Market Economies (*Francis and Taylor, Communicated*)

Workshop Attended

- Attended a ten days on **Research Methodology Course for PHD students** sponsored by ICSSR at NIT, Rourkela Odisha, 20th to 29th March 2013.
- Attended three-day workshop on **Time Series Modelling and Applications** by Madras School of Economics, Chennai, 19th to 21st August 2013.

- Attended twenty-one days**Refresher Course in Research Methodology** organized by UGC- Academic Staff College, University of Hyderabad, 18thDecember 2013 to 7th January, 2014.
- Attended one day on **CensusData Dissemination Workshop** sponsored by Office of the Director of Census Operation, Government of India at NIT Rourkela on 21st January 2015.
- Attended a four-day short term course on **Fundamentals of Applied Econometrics using STATA** organized by Department of Humanities and Social Sciences at NIT, Rourkela Odisha, 28th to 1st October 2015.
- Attended a four-day short term course on **Time Series Modelling and Forecasting: Using E-Views Package** organized by Department of Humanities and Social Sciences at NIT, Rourkela Odisha, 27th to 30th January 2016.
- Attended a three-day short term course on **Panel Data Analysis using STATA** organized by Department of Humanities and Social Sciences at NIT, Rourkela Odisha, 23rd to 25th November 2016.

Conference Paper Presented

- Presented a paper on "**Comparing Measures of core Inflation in India: Trimmed Mean and SVAR Approcah**" in the ICSSR sponsored International Conference on Shifting Paradigms in Applied Economics and Management: Course Correction organized by Faculty of Management, Shri Mata Vaishno Devi University, Jammu & Kashmir, India from 1-2 August 2014.
- Presented a paper on "**Effect of Core Inflation on Macroeconomic Performance of India**" in the 2nd International Conference on Applied Economics and Business organized by Faculty of Management, Shri Mata Vaishno Devi University, Jammu & Kashmir, India from 28-29 July 2016.
- Presented a paper on "**Dynamic Relationship between Headline and Core Inflation in India: An Empirical Investigation**" in 53rd Annual Conference of TIES organized by National Institute of Science Education and Research, Bhubaneswar, Odisha, India from 22-24 December 2016.

Resume

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MA: Applied Economics, Pondicherry Central University, Puducherry, 2012, First Class

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